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Challenges in Monitoring and Maintaining the Health of Pilots Engaged in Telewarfare

Hernando J. Ortega, Jr., MD, MPH

The growth in the use of remotely piloted aircraft (RPA), also referred to as unmanned aerial vehicles or "drones", has had a significant impact on overseas contingency operations. As noted by Drs. Otto and Webber in this issue of the *Medical Surveillance Monthly Report*, RPA operations began in earnest after the 9/11 terrorist attacks on the World Trade Center. At that time, very little was known about the stressors of, or the requirements for, these operations. Demand for RPA pilots has been increasing and currently, the Air Force is training more RPA pilots than fighter and bomber pilots combined.

Although RPA are often referred to as being unmanned, these systems require the support of teams of highly trained and experienced service members on the ground, including the RPA pilot. As advances in technology have enabled pilots to control aircraft without physically accompanying them, distinct challenges have emerged as a result of removing pilots from the physical battlespace. Traditionally, military operations have been expeditionary in nature, with large numbers of service members deployed overseas. This deployment paradigm often fosters the development of organizational identity and unit cohesion, both of which have been demonstrated to help service members cope with the stresses of combat. However, these elements are lacking in RPA pilots. In addition, RPA pilots face unique stressors related to the impact of fighting a war at the office and going home to a family at night. Last, the continually increasing demand for RPA support has lead to manning issues; RPA pilots are faced with rotating shifts and long hours which contribute to stress, sleep issues, and other negative consequences.

In 2008, stories began to emerge in the lay press about "war stress" among RPA pilots in the Air National Guard and media reports have continued to appear regarding mental health issues in this community.[1,2] These reports cited research by the U.S. Air Force School of Aerospace Medicine (USAFSAM) and the Performance Enhancement Directorate. In 2006, Dr. Anthony Tvaryanas and colleagues conducted the first comprehensive analysis of the human stressors involved in RPA operations.[3,4] Continued surveillance and research into the health and well-being of RPA pilots have offered flight surgeons and line leaders improved insight into their mental health needs. This information has also informed policy changes such as the dedication of additional mental health resources to this community.

Against this backdrop, Drs. Otto and Webber have objectively quantified the state of RPA pilots with regard to mental health (MH) endpoints (as represented by ICD-9-CM diagnoses assigned by medical providers). Their results demonstrate that Air Force RPA pilots are receiving mental health diagnoses at rates equivalent to other Air Force pilots who have deployed and at lower rates than other Air Force personnel.

The findings of this study validate several key principles of human performance developed and applied by aerospace medicine since its inception in the early 20th century. For example, the rigorous selection process aviators undergo and the ongoing operational medical support they receive are two factors (of several) which likely impact their health and operational performance; sustained vigilance and application of these principles will continue to be the cornerstone of maintaining health and optimal performance of the "human weapon system" involved in aerial combat, no matter how combat is prosecuted. *Volanti subvenimus*.

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Mental Health Diagnoses and Counseling Among Pilots of Remotely Piloted Aircraft in the United States Air Force

Jean L. Otto, DrPH, MPH; Bryant J. Webber, MD (Capt, USAF)

Remotely piloted aircraft (RPA), also known as drones, have been used extensively in the recent conflicts in Iraq and Afghanistan. Although RPA pilots in the U.S. Air Force (USAF) have reported high levels of stress and fatigue, rates of mental health (MH) diagnoses and counseling in this population are unknown. We calculated incidence rates of 12 specific MH outcomes among all active component USAF RPA pilots between 1 October 2003 and 31 December 2011, and by various demographic and military variables. We compared these rates to those among all active component USAF manned aircraft (MA) pilots deployed to Iraq/Afghanistan during the same period. The unadjusted incidence rates of all MH outcomes among RPA pilots (n=709) and MA pilots (n=5,256) were 25.0 per 1,000 person-years and 15.9 per 1,000 person-years, respectively (adjusted incidence rate ratio=1.1, 95% confidence interval=0.9-1.5; adjusted for age, number of deployments, time in service, and history of any MH outcome). There was no significant difference in the rates of MH diagnoses, including post-traumatic stress disorder, depressive disorders, and anxiety disorders between RPA and MA pilots. Military policymakers and clinicians should recognize that RPA and MA pilots have similar MH risk profiles.

Remotely piloted aircraft (RPA), denoted previously in the U.S. Air Force (USAF) as unmanned aerial vehicles, and known colloquially as drones, joined the aircraft inventory of the U.S. military in the 1960s. RPA pilots in the USAF were designated with a unique specialty code in October 2003, corresponding to the expanding role of these aircraft in Operations Enduring Freedom (OEF) and Iraqi Freedom/New Dawn (OIF/OND). Flight hours for the MQ-1 Predator—the premier intelligence, surveillance, and reconnaissance RPA platform in the USAF—increased tenfold from 2003 to 2009.[1] The psychological impact of this new "telewarfare" on RPA crew members has been the subject of reports in the popular press,[2,3] with some reports claiming higher rates of post-traumatic stress disorder (PTSD) among RPA crew members as compared to their counterparts deployed to the combat theater.[4]

Although a USAF white paper dismissed this claim as "sensational,"[5] the psychological health of RPA crew members remains a topic of military public health and operational concern. Research by Chappelle and colleagues at the USAF School of Aerospace Medicine, Department of Neuropsychiatry, has demonstrated high levels of stress and fatigue among the pilots, sensor operators, and image analysts who comprise the RPA crews. Among 600 crew members of the weapon-deploying Predator and Reaper RPAs who completed a voluntary survey, 15.3% reported feeling very or extremely stressed and 19.5% reported high emotional exhaustion. Among 264 crew members of the RQ-4 Global Hawk, a non-weapon-deploying RPA, these proportions rose to 19.4% and 33.0%, respectively.[6] At the Brookings Institution in 2012, Chappelle noted that 4% of active duty RPA pilots were at "high risk for PTSD" based on this survey. Although this represents a substantial number of service members, it is lower than the 12-17% of soldiers returning from OEF or OIF/OND who are placed in this high-risk category based on post-deployment questionnaires.[7]

Along with witnessing traumatic experiences, such as those associated with PTSD in traditional combat, RPA crew members may face several additional challenges, some of which may be unique to telewarfare: lack of deployment rhythm and of combat compartmentalization (i.e., a clear demarcation between combat and personal/family life);[5] fatigue and sleep disturbances secondary to shift work;[8] austere geographic locations of military installations supporting RPA missions;[6] social isolation during work, which could diminish unit cohesion and thereby increase susceptibility to PTSD;[9] and sedentary behavior with prolonged screen time, implicated as psychological challenges in the adult video gaming community.[10]

This retrospective cohort study is the first to document the frequencies, incidence rates, and trends of mental health (MH) outcomes among RPA pilots within the active component of the USAF, and how these rates compare to those among manned aircraft (MA) pilots (fixed wing and rotary wing) and among airmen in other USAF occupations during the same time period. For the purposes of this study, "combat" is defined broadly as actual or remote deployment to a combat zone, and not necessarily as engagement with enemy combatants.

METHODS

The surveillance period was 1 October 2003—the date at which an airman could first be identified as an RPA pilot by Air Force Specialty Code (AFSC)—through 31 December 2011. The surveillance population included service members who had

served at any time in the active component of the USAF.

RPA pilots were defined by the following AFSCs: 11U (RPA pilot); 18A (attack RPA pilot); 18G (generalist RPA pilot); 18R (reconnaissance RPA pilot); and 18S (special operations RPA pilot). MA pilots were defined as airmen deployed to OEF or OIF/OND for greater than 30 days and who had one of the following AFSCs: 11B (bomber pilot); 11F (fighter pilot); 11G (generalist pilot); 11H (rescue pilot); 11M (mobility pilot); 11R (reconnaissance/surveillance/electronic warfare pilot); and 11S (special operations pilot). A pilot could appear in only one cohort during the surveillance period; pilots who met criteria for both RPA and MA were classified as RPA pilots.

RPA pilots were eligible to receive a MH outcome during a window beginning 30 days after designation as an RPA pilot (to allow for development and diagnosis of the outcome) and ending at separation from active service or the conclusion of the surveillance period. MA pilots were eligible to receive a MH outcome during a window beginning 30 days after the start of their first OEF or OIF/OND deployment and also ending at separation from active service or the conclusion of the surveillance period. Pilots with a MH outcome recorded prior to the start of this window were considered prevalent cases and therefore were ineligible to become incident cases for that specific MH outcome. Those diagnosed with more than one MH outcome during the surveillance period were considered incident cases in each category for which they met case-defining criteria, but they were considered an incident case only once for any specific MH outcome. Time-sensitive covariates, such as age, were determined at the start of the surveillance period or, for those who entered after this time, at entry to active military service.

MH outcomes were categorized into two groups: actual mental health diagnoses defined by ICD-9-CM codes (e.g., adjustment disorders, alcohol abuse/dependence, anxiety disorders) and mental health counseling defined by V-codes and E-codes (e.g., suicide ideation/attempt, partner relationship problems, family circumstance problems). For all MH outcomes other than suicide attempt or ideation, cases were defined by at least one hospitalization record with the relevant diagnosis in the first or second diagnostic position, or two records of ambulatory encounters within 180 days with the relevant diagnosis in the first or second diagnostic position, or one ambulatory encounter in a psychiatric or MH care specialty setting with the relevant diagnosis in any diagnostic position **(Table 1)**. Cases of "suicide attempt" and "suicide ideation" were defined by just one ambulatory encounter or hospitalization with that diagnosis. As implied by the name, the category "all" outcomes refers to the total number of times that pilots satisfied a case definition for the outcome of interest, whereas "any" refers to the number of unique individuals who satisfied the case definition for at least one of the outcomes.

TABLE 1. Mental health outcomes and case-defining diagnostic codes, V codes and E codes (ICD-9-CM)

Outcome	ICD-9-CM codes
Adjustment disorder	309.0x-309.9x (exclude 309.81)
Alcohol abuse and dependence	303.xx, 305.0x
Anxiety disorder	300.00-300.09, 300.20-300.29, 300.3
Depressive disorder	296.20-296.35, 296.50-296.55, 296.9x, 300.4, 311
Post traumatic stress disorder	309.81
Substance abuse/dependence	304.xx, 305.2x-305.9x
Suicide ideation/attempt	V62.84, E950.xx-E958.x
Partner relationship problems	V61.0x, V61.1, V61.10 (exclude V61.11, V61.12)
Family circumstance problems	V61.2, V61.23, V61.24, V61.25, V61.29, V61.8, V61.9
Maltreatment related	V61.11, V61.12, V61.21, V61.22, V62.83, 995.80-995.85
Life circumstance problems	V62.xx (exclude V62.6, V62.83)
Mental, behavioral problems and substance abuse counseling	V40xx (exclude V40.0, V40.1), V65.42

All outcomes were obtained from the electronic health care records maintained in the Defense Medical Surveillance System (DMSS) and the Theater Medical Data Store (TMDS).

We calculated incidence rates (IR) per 1,000 person-years and incidence rate ratios (IRR) with 95% confidence intervals (CI). In multivariate analysis, IRRs were adjusted for age, number of deployments, time in service, and history of any MH outcome. Time in service was determined based on the time from entry into military service to first record as an RPA pilot or a fixed wing or rotary wing pilot. All analyses were performed with STATA/IC version 11.2 (STATACorp). P-values less than .05 were considered statistically significant; all P-values were based on 2-sided tests.

RESULTS

A total of 709 USAF service members were identified as RPA pilots and 5,256 as MA pilots (including 4,786 fixed-wing and 470 rotary-wing) during the surveillance period **(Table 2)**. The two cohorts were relatively similar in terms of demographics and military characteristics. RPA pilots were predominantly male (94.6%) with an average (standard deviation) age of 32.3 (5.5) years. Nearly 86% were non-Hispanic whites, 74% were married, and 70% were company grade officers (i.e., lieutenants and captains). Compared to MA pilots, a greater percentage of RPA pilots had been deployed three or more times in any occupational capacity (48% versus 31%; $p<0.001$), had prior MH diagnoses (27% versus 16%; $p<0.001$) and had six or more years in service (75% versus 60%; $p<0.001$).

Of the 709 USAF service members who met criteria for an RPA pilot, only 82 were RPA pilots exclusively and had never been deployed. The majority of RPA pilots had been previously deployed as MA pilots. (While use of mutually exclusive cohorts is ideal, restricting the RPA cohort to those 82 pilots would have resulted in insufficient statistical power to conduct our analysis.)

Approximately 8.2 percent (n=58) of RPA pilots and 6.0 percent (n=313) of MA pilots had at least one MH outcome **(Table 3)**. The incidence rates of all MH

TABLE 2. Demographic and military characteristics of USAF RPA and MA pilots, 1 October 2003-31 December 2011

	RPA pilots		MA pilots	
	No.	%	No.	%
Total	709	100	5,256	100
Sex				
Female	38	5.4	142	2.7
Male	671	94.6	5,114	97.3
Age				
20-24	1	0.1	401	7.6
25-29	271	38.2	2,194	41.7
30-34	243	34.3	936	17.8
35-39	108	15.2	870	16.6
40+	86	12.1	855	16.3
Race/ethnicity				
White non-Hispanic	606	85.5	4,792	91.2
Black non-Hispanic	21	3.0	100	1.9
Hispanic	34	4.8	100	1.9
Asian/Pacific Islander	19	2.7	65	1.2
Other	29	4.1	199	3.8
Marital status				
Single	152	21.4	1,374	26.1
Married	526	74.2	3,752	71.4
Other	31	4.4	130	2.5
Education level				
College	500	70.5	3,308	62.9
Advanced degree	175	24.7	1,793	34.1
Other	34	4.8	155	2.9
No. of deployments				
0	82	11.6	0	0.0
1	148	20.9	2,001	38.1
2	138	19.5	1,627	31.0
3+	341	48.1	1,628	31.0
Total time deployed				
<6 months	283	39.9	1,978	37.6
6-12 months	239	33.7	1,959	37.3
13-18 months	140	19.7	935	17.8
18+ months	47	6.6	384	7.3
Military rank				
2LT-CPT	494	69.7	3,297	62.7
MAJ-COL	215	30.3	1,959	37.3
Time in USAF prior to AFSC				
<6 years	178	25.1	2,126	40.4
6-10 years	253	35.7	1,129	21.5
11-15 years	187	26.4	1,487	28.3
16+ years	91	12.8	514	9.8
Prior MH outcome	191	26.9	852	16.2

Abbreviations: AFSC, Air Force Specialty Code; MA, manned aircraft; MH, mental health; RPA, remotely piloted aircraft; USAF, United States Air Force

outcomes among RPA pilots was 25.0 per 1,000 person-years and among MA pilots was 15.9 per 1,000 person-years (adjusted IRR=1.1, 95% CI=0.9-1.5). After adjustment, RPA pilots and MA pilots had statistically equivalent incidence rates of total and individual MH outcomes evaluated **(Table 3, Figure 1)**. Adjustment disorder and depressive disorder were the two most common diagnoses in both RPA and MA pilots, while partner relationship and life circumstance problems were the two most common counseling codes.

The trend of annual rates (unadjusted) of MH outcomes among RPA pilots markedly differed from the trend among MA pilots. For example, annual rates of MH outcomes among MA pilots slowly increased throughout OEF and OIF/OND and were highest (29 per 1,000 person-years) in 2011. In contrast, among RPA pilots, annual rates remained relatively stable from 2005 through 2008, increased markedly in 2009 and 2010, and then nearly returned to baseline in 2011. Of note, each year from 2005 through 2011 (and particularly in 2009 and 2010), rates (unadjusted) of MH outcomes were higher among RPA than MA pilots **(Figure 2)**.

Finally, incidence rates (unadjusted) of any mental health outcomes were lower among RPA and MA pilots than USAF members in health care, administrative/supply, combat-specific, and "other" occupations, as well as among USAF members overall **(Figure 3)**.

EDITORIAL COMMENT

This report documents the frequencies, incidence rates, and trends of MH outcomes among RPA pilots within the active component of the USAF compared to those among USAF MA pilots during the same time period. Between October 2003 and December 2011, approximately one of every 12 RPA pilots and one of every 17 MA pilots received at least one incident MH outcome (i.e., first diagnosis of the outcome during their military careers). After adjusting for the effects of several factors that differed between the RPA and MA pilots, incidence rates among the cohorts did not significantly differ. Despite self-reports of high levels of stress and fatigue among RPA pilots, this study did not find higher adjusted rates of MH outcomes among this cohort compared to MA pilots.

RPA and MA pilots had lower unadjusted incidence rates of any MH outcome as compared to USAF members overall and to specific occupational groups within the USAF. Several factors may explain this finding. First, as a highly screened and selected group, USAF pilots are likely less prone to MH outcomes as compared to airmen in other occupations. All USAF pilots are college graduates who have passed stringent physical requirements, psychological standards, legal and behavioral

TABLE 3. Incidence rates and rate ratios of mental health outcomes by pilot type, 1 October 2003-31 December 2011

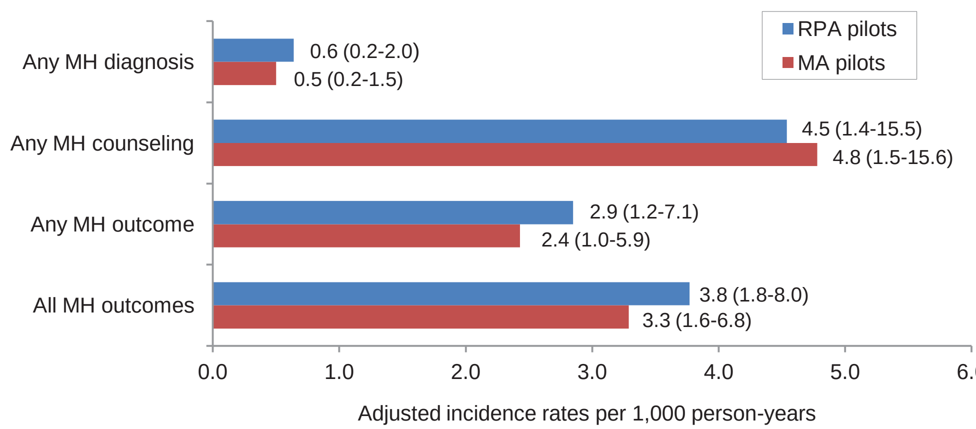
	Mental health outcomes	RPA pilots No.	RPA pilots IR[a] (95% CI)	MA pilots No.	MA pilots IR[a] (95% CI)	Unadjusted IRR (95% CI)	Adjusted IRR[b] (95% CI)
Diagnoses	Adjustment disorders	22	6.6 (4.4-10.1)	104	3.6 (2.9-4.3)	1.9 (1.2-2.9)	1.4 (0.9-2.3)
	Alcohol abuse/dependence	3	0.9 (0.3-2.7)	25	0.9 (0.6-1.3)	1.0 (0.3-3.4)	1.0 (0.4-2.7)
	Anxiety disorder	9	2.7 (1.4-5.1)	36	1.2 (0.9-1.7)	2.2 (1.0-4.5)	1.3 (0.6-2.9)
	Depressive disorder	11	3.3 (1.8-5.9)	46	1.6 (1.2-2.1)	2.1 (1.1-4.0)	1.4 (0.7-2.9)
	Posttraumatic stress disorder	3	0.9 (0.3-2.7)	20	0.7 (0.4-1.0)	1.3 (0.4-4.3)	0.6 (0.2-2.2)
	Substance abuse/dependence	1	0.3 (0.0-2.1)	1	0.0 (0.0-0.2)	8.6 (0.5-138)	---
	Any mental health diagnosis	37	10.9 (7.9-15.0)	176	6.0 (5.2-7.0)	1.8 (1.3-2.6)	1.3 (0.9-1.9)
Counseling	Suicide ideation/attempt	0	0.0	1	0.0 (0.0-0.2)	---	---
	Partner relationship problems	14	4.2 (2.5-7.1)	101	3.5 (2.9-4.2)	1.2 (0.7-2.1)	1.0 (0.5-1.7)
	Family circumstance problems	2	0.6 (0.1-2.4)	7	0.2 (0.1-0.5)	2.5 (0.5-11.8)	1.9 (0.4-9.6)
	Maltreatment related	0	0.0	4	0.1 (0.1-0.4)	---	---
	Life circumstance problems	16	4.8 (2.9-7.8)	85	2.9 (2.4-3.6)	1.6 (1.0-2.8)	1.3 (0.7-2.2)
	Mental, behavioral problems, substance abuse	4	1.2 (0.4-3.1)	34	1.2 (0.8-1.6)	1.0 (0.4-2.9)	0.7 (0.2-1.9)
	Any mental health counseling	30	8.8 (6.2-12.6)	205	7.0 (6.1-8.0)	1.3 (0.9-1.8)	1.0 (0.6-1.4)
Any mental health outcome		58	17.1 (13.2-22.1)	313	10.7 (9.6-12.0)	1.6 (1.2-2.1)	1.2 (0.9-1.6)
All mental health outcomes		85	25.0 (20.2-30.9)	464	15.9 (14.5-17.4)	1.6 (1.3-2.0)	1.1 (0.9-1.5)

Incidence rates per 1,000 person-years
Abbreviations: CI, confidence interval; IR, incidence rate; IRR, incidence rate ratio; MA, manned aircraft; RPA, remotely piloted aircraft
[a]Unadjusted incidence rates
[b]Adjusted for age, number of deployments, time in service, and history of any mental health outcome

background checks, and rigorous operational training programs.[11] Flight surgeons evaluate all pilot candidates for occupational suitability, which includes emotional and behavioral screening. Discovery of psychoses, neuroses, or personality disorders, for example, may result in disqualification.[12] Second, these findings may reflect the effects of special preventive measures for pilots. As compared to airmen in other occupations, pilots undergo more robust periodic health assessments and may have better access to care given the relatively low ratio of pilots to flight surgeons.

Conversely, the relatively low rates of mental disorder diagnoses among Air Force pilots compared to their counterparts may reflect artificial underreporting of the concerns of pilots due to detrimental career ramifications from incurring MH diagnoses (but not counseling); the career-threatening effects of MH diagnoses include removal from flying status, loss of flight pay, and diminished competitiveness for promotion. Current USAF aeromedical policy requires that pilots with a MH diagnosis be immediately "grounded," or removed from flying status. An aeromedical waiver

FIGURE 1. Adjusted incidence rates[a] of MH outcomes, by pilot type, U.S. Air Force, 1 October 2003-31 December 2011



[a]Incidence rates per 1,000 person-years with 95% confidence intervals
Abbreviations: MH, mental health; RPA, remotely piloted aircraft

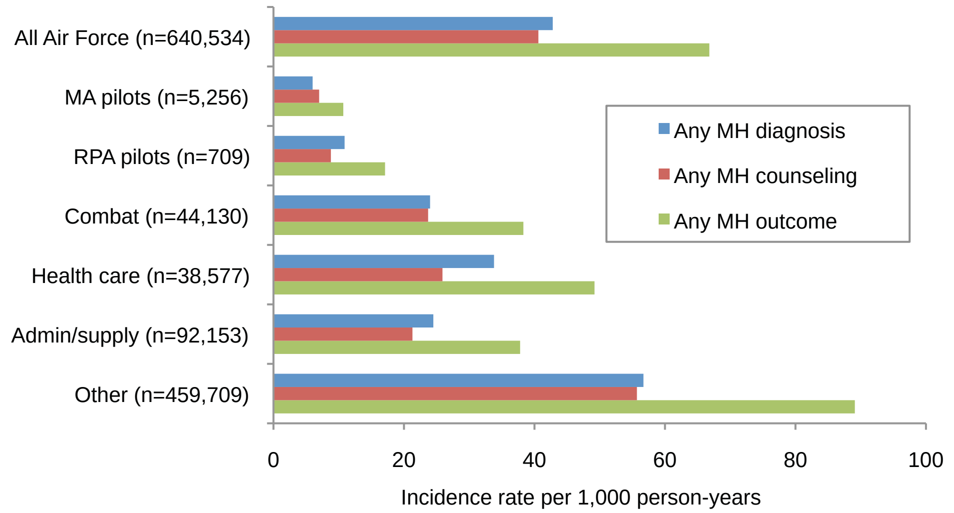
to resume flight duty cannot be submitted until the individual has been appropriately treated and has been asymptomatic and without medications for a specified time period. Although this time period varies by diagnosis and flight surgeon discretion, it typically ranges from six months to one year. A pilot with an alcohol abuse or dependence diagnosis, for example, cannot return to flying status until completion of alcohol rehabilitation, which includes abstinence training and 90 days in a post-treatment aftercare program.[13] Some MH diagnoses may require a medical evaluation board for the individual to remain in the USAF.[14]

Several important factors distinguish these findings from those reported

FIGURE 2. Unadjusted incidence rates[a] of MH outcomes[b], by pilot type, U.S. Air Force, 1 October 2003-31 December 2011

[a]Incidence rates per 1,000 person-years
Abbreviations: MA, manned aircraft; MH, mental health; RPA, remotely piloted aircraft

FIGURE 3. Unadjusted incidence rates[a] of MH outcomes by USAF occupation, 1 October 2003-31 December 2011



[a]Incidence rates per 1,000 person-years (non-RPA and non-MA pilots are included in "Other")
Abbreviations: MA, manned aircraft; MH, mental health; n, number of unique individuals; RPA, remotely piloted aircraft; USAF, United States Air Force

in case series and the lay press. The results presented here reflect healthcare provider-assigned clinical diagnostic codes entered into the electronic medical records of service members. In contrast, other published studies have relied upon self-reported data from anonymous questionnaires, which reflect symptoms rather than formal diagnoses.

The findings of this report should be interpreted within the context of at least four limitations. First, capture of incident MH outcomes may be incomplete. Incident cases were ascertained from ICD-9-CM diagnostic codes recorded on standardized administrative records of medical encounters. As such, the findings only reflect outcomes that were clinically detected. To the extent that pilots received care from sources not captured by DMSS (e.g., private practitioner), or did not seek care (e.g., due to career concerns outlined above, social stigmas, or the unavailability of MH providers), the numbers reported here are underestimates. Moreover, diagnoses used to identify cases for this report were not confirmed by medical record review. In addition, while TMDS captures most MH outcomes diagnosed in deployed medical facilities, this data source may be incomplete. However, since the percentage of total person-time deployed was small and comparable—6% among MA pilots and 5% among RPA pilots—this is unlikely to introduce bias.

Second, analyses for this report were limited to the medical encounters of active component members of the USAF only. This report does not contain data for the Air Force Reserves or Air National Guard, nor does it include data on other services within the active component (i.e., Army, Navy, and Marine Corps). Its findings, therefore, may not be generalizable to other military components and services.

Third, this study utilized AFSCs as surrogates for exposure (i.e., remote combat or traditional combat). In reality, both RPA and MA pilots likely experienced differential levels of exposure. An ideal analysis would incorporate hours exposed to remote combat in the RPA cohort and the hours exposed to traditional combat in the MA cohort, but such granular data were unavailable. Instead, deployment and demographic records were employed to determine exposure time, and multivariate analysis was used to control for deployment duration. Even if hours engaged in combat were identical in the two cohorts, combat experiences may diverge. Both RPA and MA pilots conduct different types of missions with different objectives (e.g., conducting surveillance or deploying munitions). Given the lack of evidence linking type of aerial mission with likelihood of mental health outcomes, we did not stratify within each cohort. In addition, airmen were classified as RPA pilots even if they also met criteria as MA pilots during the surveillance period; without mutual exclusivity of the cohorts, there may be bias toward the null.

Fourth, the findings are based on incident, dichotomous MH outcomes. Recurrent outcomes were not assessed, and the diagnostic codes used to determine cases do not reflect the clinical severity of the outcome.

In summary, the findings of this report suggest that remote combat does not increase the risk of MH outcomes beyond that seen in traditional combat. Military policymakers and clinicians should recognize that RPA pilots have a similar MH risk profile as MA pilots. Although unadjusted rates of MH outcomes among both cohorts of pilots were much lower than rates among those in other USAF occupations, further research is needed to evaluate the impact of aeromedical policy on these rates, as well as the effect of remote combat on other RPA crew members.

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External Causes of Traumatic Brain Injury, 2000-2011

This report summarizes frequencies, distributions, and trends of external causes of traumatic brain injuries (TBIs) that are recorded on standardized records of medical encounters of U.S. military members. Causes of TBI were reported for 100 percent of cases hospitalized in military facilities, but were relatively infrequently reported in other treatment settings (i.e., military outpatient facilities, combat theater and civilian medical facilities). During 2008-2011 in all clinical settings combined, 24,115 service members had TBI case-defining medical encounters with recorded injury causes. Accidents represented 74 percent of recorded causes; the most frequently reported specific causes were motor vehicle traffic accidents (20%), falls (20%), and being struck by or struck against an object (15%). Similar proportions of TBIs were reportedly due to intentional "assaults" unrelated to war (11%) and "battle injuries" (11%). Assaults were second only to motor vehicle accidents as reported causes of TBIs treated in civilian hospitals. Some TBIs reportedly due to accidents with guns/explosives were likely combat injuries that were miscoded in military hospitals. The doubling of the number of combat-related TBIs reported from Iraq/Afghanistan between 2010 and 2011 undoubtedly reflects the U.S. military's increased focus on identifying and treating TBIs among deployed military members.

Traumatic brain injury (TBI) is damage to and functional impairment of the brain caused by a sudden external force. Surveillance of TBIs among U.S. military members is conducted by monitoring numbers and rates of TBI-related diagnoses in routinely reported records of medical encounters. "Concussion" and "head injury, unspecified" account for approximately two-thirds of all incident TBI-related diagnoses recorded during hospitalizations and ambulatory visits of U.S. service members.[1]

TBI has long been an important source of morbidity among U.S. service members. Although TBI has been referred to as the "signature injury" of the wars in Iraq and Afghanistan, rates of TBI-related hospitalizations have not significantly increased from before to during those conflicts.[1,2] A previous *MSMR* report indicated that, since the beginning of the wars in Iraq/Afghanistan, fewer than five percent of all TBI-related hospitalizations of active component service members were related to "battle casualties" (per causes of injuries documented in standardized medical records).[3] In general, the most frequent causes of TBIs among both military members and same-aged civilians have been accidents (e.g., motor vehicle crashes, falls, strikes by/against objects) and intentional assaults (e.g., fights, brawls).[4,5]

This report summarizes the frequencies, distributions, and trends of external causes of TBIs that are recorded on standardized records of medical encounters of U.S. military members, including records of treatment provided in combat theaters. It assesses the completeness of recording of external causes of TBIs in various clinical settings and describes the distribution of causes of TBIs by gender and in relation to clinical severity.

METHODS

The surveillance period was 1 January 2000 to 31 December 2011. The surveillance population included all individuals who served in the active component of the U.S. military any time during the surveillance period.

For surveillance purposes, TBI cases were defined by records of hospitalizations or ambulatory visits of active component members that included an ICD-9-CM diagnosis code indicative of a traumatic brain injury (per the Department of Defense standard case definition)[6] in the primary (first-listed) diagnostic position; or a TBI indicator diagnosis in any non-primary diagnostic position, if the primary (first-listed) diagnosis during the same encounter was indicative of an injury (to the brain or any other anatomical entity). Of note, individuals whose only TBI-related diagnoses during the surveillance period were for injuries that occurred in the past, i.e., "post-concussion syndrome" (ICD-9-CM: 310.2), "personal history of TBI" (ICD-9:V15.5), were not considered cases for this analysis.

Only one TBI-related medical encounter per individual was included for analysis. If individuals had more than one TBI case-defining medical encounter during the period, the record used for analysis was the earliest that included both a TBI case-defining diagnosis and an external-cause-of-injury code. If cause-of-injury codes were absent from all records of TBI-related medical encounters of cases, the record from the earliest TBI-related encounter of each case was used for analysis.

External causes of TBIs were ascertained from external cause of injury codes (ICD-9-CM E codes) reported on records of TBI-related inpatient and outpatient encounters in military and civilian treatment facilities; and from cause of injury codes (STANAG codes) reported on records of TBI-related hospitalizations in military hospitals in signatory nations of the North Atlantic Treaty Organization's Standard Agreement on cause-of-injury coding (STANAG 2050). The ICD-9-CM E code and STANAG cause-of-injury classification systems have been described, compared, and contrasted elsewhere.[7] If TBI-related

hospitalization records included both E codes and STANAG codes, the STANAG code was considered indicative of the cause of the respective TBI.

External causes of TBIs were classified into nine categories based on whether the injuries were intentionally inflicted or accidental and based on the circumstances or activities associated with the injuries **(Table 1)**. An "all other causes" category combined non-specific or infrequent causes of TBI, including "intentionally self-inflicted", which accounted for less than one percent of TBI-related encounters with recorded causes. TBIs for which the only causal information was E849 ("place of occurrence") were considered to have missing causes.

External causes of TBI were evaluated in three treatment settings: military treatment facilities in the U.S., Europe, Korea and Japan; civilian facilities (contracted/reimbursed care) in U.S. and overseas locations; and deployed medical facilities in the combat theaters of Iraq and Afghanistan.

RESULTS

During the 12 years between 2000 and 2011, 175,290 active component service members had at least one TBI diagnosis (in any diagnostic position) that was associated with a contemporaneous injury. These individuals had 155,486 TBI case-defining medical encounters with primary (first-listed) diagnoses of TBI or other injuries; of these TBI case-defining medical encounters, 85 percent were ambulatory visits, and 42 percent were in non-military facilities **(Figure 1)**.

Completeness of external cause recording

During the 12-year period, more than two-thirds of all records of TBI case-defining medical encounters did not include cause-of-injury codes. The completeness of reporting of external causes of TBIs sharply varied across clinical settings **(Figure 2)**. For example, of TBIs treated in non-deployed military treatment facilities (MTFs), causes of TBI-related injuries were reported for 100 percent (7,982/7,983) of hospitalized but only 40 percent (29,282/72,405) of outpatient treated cases.

Because codes indicative of causes of TBIs were infrequently reported in records of medical encounters in combat theater deployed and civilian medical facilities, especially prior to 2008 **(Figure 2)**, analyses of causes of TBIs diagnosed in deployed and civilian medical facilities were restricted to the period 2008 through 2011. During this period, the proportions of records of TBI case-defining encounters that included cause-of-injury codes, by clinical setting, were 39% of 2,118 hospitalizations in civilian facilities; 23% of 24,733 encounters in civilian ambulatory clinics; and 15% of 6,950 encounters in medical facilities in combat theaters.

Causes of injuries

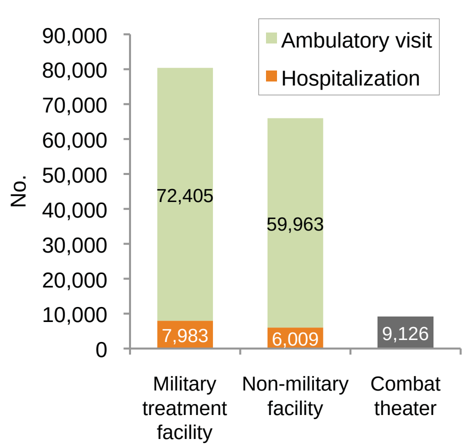
During 2008-2011 in all clinical settings combined, 24,115 service members had TBI case-defining medical encounters with recorded injury causes. Accidents represented 74 percent of recorded causes; the most frequently reported specific causes were motor vehicle traffic accidents (20%), falls (20%), and being struck by or struck

TABLE 1. Cause of injury categories as defined by external cause of injury codes (E codes) and STANAG codes[a]

External cause category	STANAG codes[a]	E code (ICD-9-CM)
Battle injury	STANAG 300-479 (except with Trauma 4). Trauma 0 or 1 plus STANAG 500-999	E990-E999, E979
Assault (non-battle), legal intervention	Trauma 2 or 3 plus STANAG 500-999	E960-E978
Gun/explosive accident	STANAG 480-599 (except with Trauma 4)	E922, E923, E928.7
Fall	Trauma 5-9 plus STANAG 900-929	E833-E835, E888, E880-E885, E886.9, E929.3
Struck by/machinery	Trauma 5-9 plus STANAG 660-699	E916, E917.1-E917.4, E917.6-E917.9, E918-E921, E836, E837
Motor vehicle traffic	STANAG 100-149	E810-819, E929.0
Other transportation accident	STANAG 000-059, 150-199	E800-E807, E820-E832, E838-E848
Sports/athletics	STANAG 200-249	E006-E010, E917.0, E917.5, E886.0
All other causes	Trauma 4 plus STANAG 300-999, all other STANAG codes not listed above	All other E codes except E849
No cause recorded	No STANAG code	No E code or E849 only

[a]Per United Nations Standard Agreement (STANAG) 2050. "Trauma" indicates the "general class of trauma" per the first digit of each 4 digit-STANAG code. STANAG codes were available from records of military hospitalizations only. STANAG codes were prioritized over E codes when both were present in the same medical record. Self-inflicted injuries are included in "all other causes".

FIGURE 1. Number of TBI case-defining medical encounters[a] (n=155,486), by clinical setting of treatment, active component, U.S. Armed Forces, 2000-2011



[a]Medical encounters (one per individual) with a TBI indicator code in any diagnostic position. Only encounters with a primary (first-listed) diagnosis of an injury (ICD-9-CM: 800-999) were retained for analysis.

against an object (15%). Among TBI case-defining medical encounters with recorded causes, similar numbers of injuries were reportedly due to intentional "assaults" unrelated to war (n=2,526, 11%) and "battle injuries" (n=2,711, 11%) **(data not shown)**.

Military treatment facilities (non-deployed): During 2000-2011, of the nearly 8,000 TBIs that were treated in fixed (e.g., not deployed or at sea) military hospitals, 81 percent were reportedly due to accidental injuries **(Figure 3)**. The most frequently reported cause-of-injury codes were motor vehicle traffic accidents (32%), gun/explosive accidents (24%) and falls (13%). Six percent of TBI-related injuries treated in fixed military hospitals were attributed to battle injuries. Notably, of the eight percent of TBI-related hospitalizations with "other" causes of injury, approximately one-quarter (n=192, 26%) were reported as unintentional injuries due to "fighting, not elsewhere classified, including horseplay" **(data not shown)**.

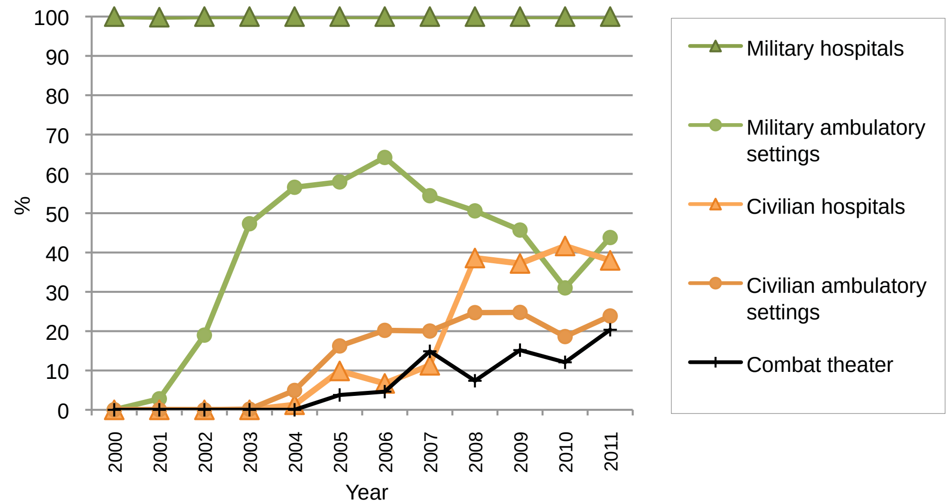
A majority (60%) of the records of TBI case-defining ambulatory visits in fixed military medical facilities had no cause-of-injury codes **(Figure 3)**. Accidents were the most frequently reported causes of injuries (76 percent) on records of TBI case-defining ambulatory visits with cause-of-injury codes (n=29,282) **(data not shown)**. In comparison to the percentage distribution of causes of TBIs that were treated in military hospitals, TBIs treated during ambulatory visits with reported causes were relatively less frequently due to motor vehicle accidents (15%) and gun/explosive accidents (1%) and more frequently due to falls (22%), accidental strikes by or against objects (19%) and assaults (11%) **(data not shown)**.

Among service members treated in military medical facilities during 2000-2011, the numbers of first-time TBIs due to motor vehicle traffic accidents declined steadily in hospitals but remained relatively stable in ambulatory settings **(Figures 4a, 4b)**. Notable increases in numbers of TBIs due to combat injuries and gun/explosive accidents began in 2003 and 2006 in hospitalized and ambulatory settings, respectively. In contrast, annual numbers of TBIs due to falls and accidental strikes by or against objects were relatively stable during the period **(data not shown)**.

Over the entire period, nearly all (96%) TBI case-defining hospitalizations due to gun/explosive accidents were treated at Landstuhl Regional Medical Center (LRMC) in Germany; LRMC is the principal hospital to which war-wounded service members are evacuated. By comparison, only 12 percent of TBI case-defining hospitalizations due to falls were treated at Landstuhl **(data not shown)**.

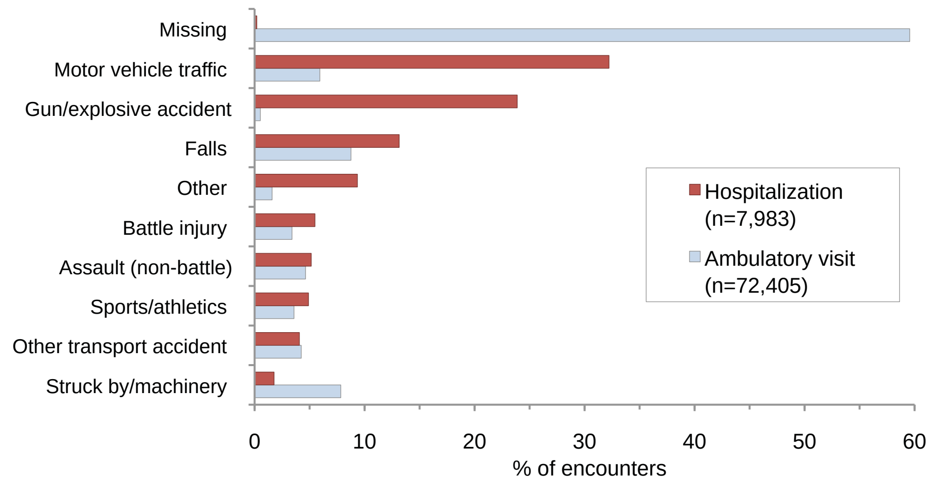
Civilian treatment facilities: During 2008-2011, cause of injury codes were not recorded on approximately three-quarters of all records of TBI case-defining encounters treated in non-military facilities **(Figure 5)**. Accidents were the most frequently reported causes of injuries (78%) on records with causes of injuries that documented TBI case-defining inpatient (n=823) and outpatient (n=5,692) encounters in civilian facilities **(data not shown)**. Motor vehicle traffic accidents were by far the leading specific cause of TBI case-defining encounters in civilian inpatient (45%) and outpatient (35%) settings. Assaults were the second

FIGURE 2. Percentage of TBI case-defining medical encounters with any cause of injury code, by clinical setting, active component, U.S. Armed Forces, 2000-2011



[a]Combat theater medical encounters were incompletely reported prior to 2008

FIGURE 3. Percentage of TBI case-defining medical encounters with a specific cause[a] or with no cause recorded, by clinical setting of treatment, military treatment facilities, active component, U.S. Armed Forces, 2000-2011



[a]"Assault (non-combat)" and "combat" are intentional injuries. All others are unintentional (accidental) injuries.

and third leading causes of TBI case-defining hospitalizations (19%) and ambulatory visits (16%), respectively. In comparison to the experience in military facilities, the proportions of case-defining TBIs treated in civilian facilities that were reportedly due to battle injuries and gun/explosive accidents were small. Of case-defining TBIs due to "other transportation accidents", those treated in civilian facilities were primarily due to off-road vehicles and bicycles, while the majority of those treated in military facilities were caused by military parachuting accidents.

Combat theater: During 2008-2011, medical encounters in the combat theaters of Iraq/Afghanistan accounted for 10 percent of all TBI case-defining medical encounters overall but 34 percent of all case-defining TBIs reportedly due to "battle injuries". Of the records that documented 6,950 TBI case-defining medical encounters in combat theaters, only 15 percent (n=1,051) included cause-of-injury codes; of causes of injuries that were reported, nearly all were attributed to combat injuries (88%) or gun/explosive accidents (7%) **(Figure 6)**. Between 2010 and 2011, numbers of TBI-related encounters due to combat injures more than doubled while numbers due to gun/explosive accidents increased only slightly.

Severity

Of case-defining TBIs treated in fixed military hospitals during 2000-2011, those reported as "severe" or "penetrating" brain injuries (per ICD-9-CM diagnosis codes) were relatively frequently caused by gun/explosive accidents (43%), while those reported as "moderate" (15%) or "mild" (26%) brain injuries were relatively frequently due to motor vehicle accidents and falls **(Figure 7)**. In other clinical settings, such relationships were difficult to assess because the causes of injuries were so frequently unreported.

FIGURE 4. Number of TBI case-defining medical encounters attributable to selected causes of injury, active component, U.S. Armed Forces

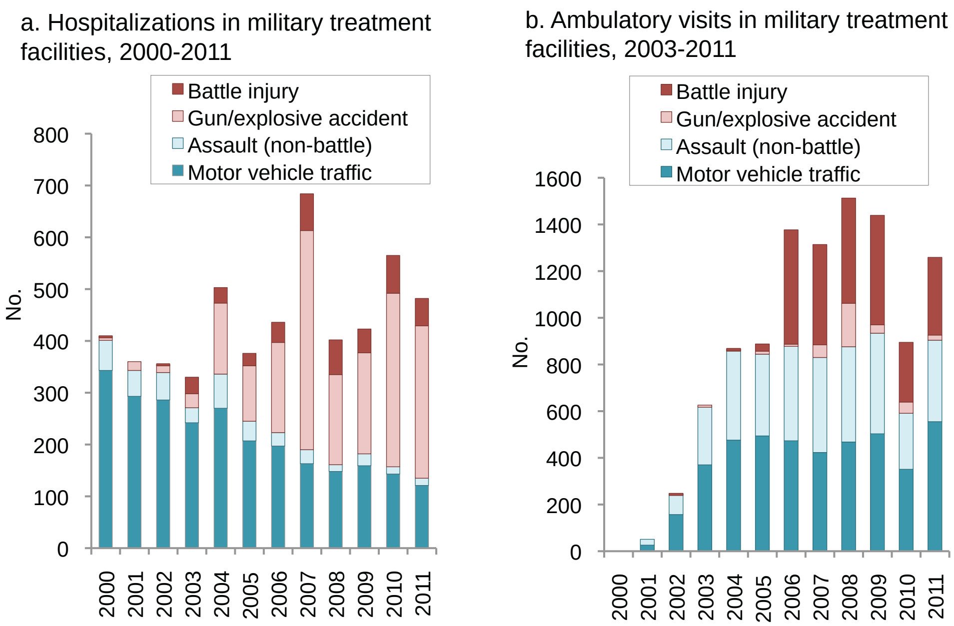
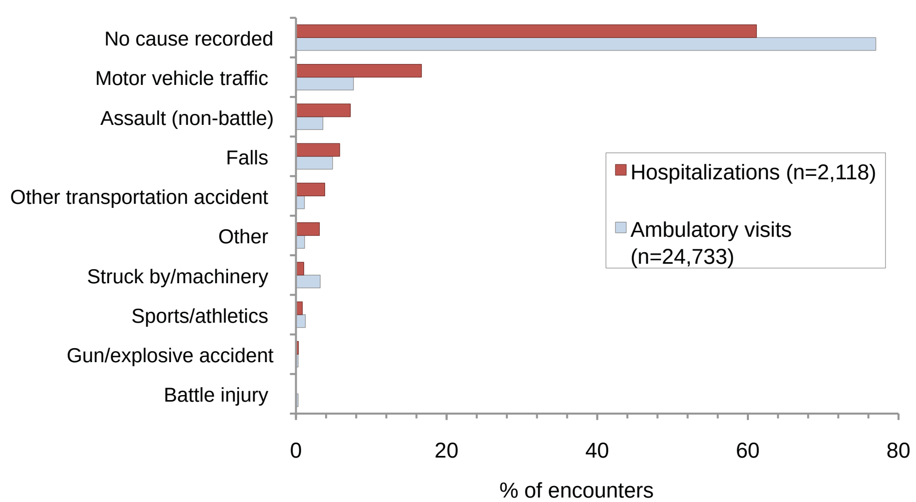
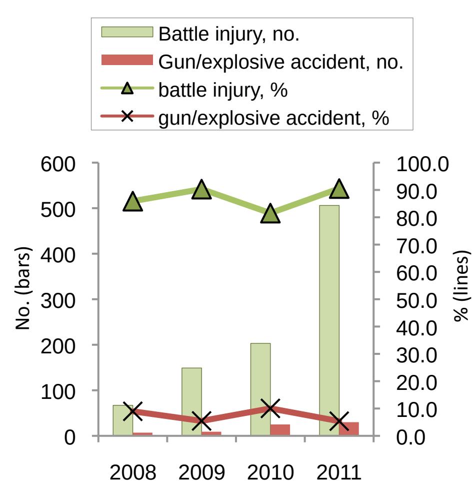


FIGURE 5. Percentage of TBI case-defining medical encounters in civilian treatment facilities a specific cause[a] or with no cause recorded, by clinical setting of treatment, active component, U.S. Armed Forces, 2008-2011



[a]"Assault (non-combat)" and "combat" are intentional injuries. All others are unintentional (accidental) injuries.

FIGURE 6. Of TBI case-defining medical encounters in the combat theater with recorded causes of injury (n=1,051), number and percent due to "battle injury" and "gun/explosives accident", active component, U.S. Armed Forces, 2008-2011



Causes of injuries, by gender

Of all case-defining TBIs treated in all clinical settings and with documented causes, those among men compared to women were relatively more often intentionally inflicted (i.e., assaults, battle injuries) **(data not shown)**. Of note, of all case-defining TBIs with reported causes, relatively more were due to gun/explosive accidents among males (12%) than females (2%) and to motor vehicle traffic accidents among females (30%) than males (21%) **(data not shown).**

EDITORIAL COMMENT

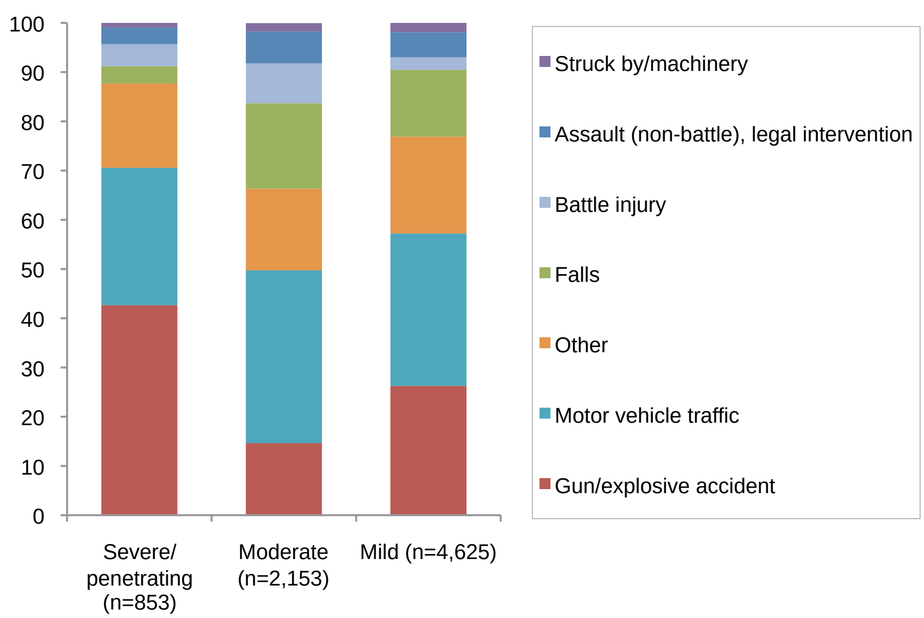
This report documents that, since 2000, accidents — and in particular, motor vehicle accidents, falls, and strikes by or against objects — are the most frequent causes of the first traumatic brain injuries that require medical care of military service members while in active service.

Assaults are another leading cause of TBIs among military members. Previous *MSMR* reports have documented that traumatic brain injuries are the most frequent primary diagnoses during assault-related hospitalizations of military members.[8] In this report, assaults accounted for 19 percent of all TBI-related hospitalizations (with documented TBI causes) of military members in civilian hospitals. Assaults were second only to motor vehicle accidents as reported causes of TBIs that required civilian hospital care.

The findings of this report should be assessed with consideration of its limitations. For example, in this report, gun/explosive accidents accounted for relatively more of the TBIs that received inpatient treatment in military hospitals (24%) than those treated in other clinical settings. It is likely, however, that at least some TBIs reportedly due to "accidental injuries" were in fact combat injuries that were miscoded. Of note in this regard, nearly all hospitalized TBI cases reportedly due to gun/explosive accidents received care at Landstuhl Regional Medical Center in Germany. For a majority of such cases, the causes of the injuries are reported as "guns, explosives and related agents, except when used as instrumentalities of war in wartime" (per STANAG 2050). Amoroso and colleagues have observed that the STANAG cause-of injury coding system achieves greater specificity than ICD-9-CM E codes because the STANAG system requires separate coding of the intent (e.g., accident) and the cause (e.g., explosive). However, the STANAG system increases the possibility of error.[7] Of specific interest in this regard, there are hundreds of permutations of STANAG codes that can indicate that guns, explosives and other instrumentalities of war were causes of related injuries. Also, compared to the reported causes of TBIs among military hospitalized cases, gun/explosive accidents were relatively much less frequently reported on records of TBIs that were treated in military combat theaters (using E rather than STANAG cause of injury codes). Finally, the distinction between battle casualties and accidents could in some cases be obscured by the unconventional nature of combat during the recent wars in Iraq/Afghanistan. In summary, if some TBIs from battle injuries were miscoded as due to accidents, the overall numbers and proportions of TBIs due to battle injuries that are reported here are underestimates.

In analyses of administrative data, morbidity trends often reflect changes in policies and practices, e.g., introductions of new screening programs, mandatory medical tests. The doubling of the number of combat-related TBIs reported from Iraq/Afghanistan between 2010 and 2011 undoubtedly reflects, at least in part, the sharp increase in the focus of the U.S. military on identifying and treating traumatic brain injuries among deployed military members. In July 2010, the Department of Defense issued "Policy Guidance for the Management of Concussion/Mild Traumatic Brain Injury in the Deployed Setting."[9,10] [DTM 09-033 and DoDI 6490.1] The policy mandates TBI screening for deployed service members exposed to "potentially concussive events" and medical evaluation for those who sustained physical injury, endorsed TBI symptoms (e.g., headache, ear ringing), or were <50 meters from a blast. A July 2012 report to Congress on the implementation of the policy states that of service members reported with potentially concussive events during August 2010 through August 2011, 15% received a subsequent medical diagnosis of concussion.[11]

FIGURE 7. External causes of traumatic brain injury (TBI), by severity of TBI diagnosis[a], among TBI-related hospitalizations in fixed military treatment facilities, active component, U.S. Armed Forces, 2000-2011



[a]Severity determined by ICD-9-CM codes

The report also notes that between July 2010 and December 2011, the proportion of concussions due to vehicle-related events increased, while the proportion due to blast events decreased.[11]

Another important limitation of this report is that only one TBI-related encounter per individual was included in analysis. The restriction was used because of the difficulty, while using administrative data, in distinguishing new TBI events from follow-up treatments and rehabilitation of prior TBIs. Because many military members sustain multiple TBIs while in service, the numbers of TBIs documented here underestimate the total numbers of TBIs among military members. Also, because the causes of TBIs undoubtedly vary across military service careers, the distribution of external causes of TBIs documented here likely varies from the distribution of causes of TBIs overall.

Finally, TBIs treated in military hospitals are assigned an external cause code of injury nearly 100 percent of the time. The high compliance with cause of injury coding on records of injury-related hospitalizations in U.S. military hospitals has been previously noted.[7] However, in 2011, a majority of records of TBI case-defining encounters in U.S. military outpatient clinics lacked cause-of-injury codes. In addition, many of the cause of injury codes that were included on records had little useful information. For example, in this analysis, records of more than 1,500 TBI case-defining encounters indicated that the subject injuries were due to "unspecified" or "other" accidents. The impending implementation of ICD-10 has the potential to improve the usefulness of coding of causes of injuries in general – and TBIs in particular. In the meantime, more complete, precise, and accurate reporting of the causes of TBI-related events is indicated to inform TBI prevention priorities, policies, practices, and research initiatives.

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Brief Report

Mid-Season Influenza Vaccine Effectiveness for the 2012-2013 Influenza Season

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The Armed Forces Health Surveillance Center (AFHSC), Naval Health Research Center (NHRC) and United States Air Force School of Aerospace Medicine (USAFSAM) conduct annual mid-season influenza vaccine effectiveness (VE) analyses for the Department of Defense (DoD). As each organization conducts influenza surveillance on different populations, their analyses provide a unique opportunity to assess influenza VE among service members, dependents and civilians. This report describes the findings for the middle of the 2012-2013 influenza season.

Assessment of VE was performed by three case-control approaches in which cases were individuals with positive laboratory tests for influenza. First, the AFHSC used the Defense Medical Surveillance System (DMSS) to identify all active component, non-recruit service members during 1 September 2012 to 14 February 2013. Health Level 7 data in the DMSS was used to identify influenza cases that were laboratory confirmed by a rapid influenza test, reverse transcriptase polymerase chain reaction (RT-PCR), or viral culture. Controls were active component service members with health care encounters for musculoskeletal conditions (without respiratory diagnoses) and were matched to cases by sex, age, date of diagnosis (+/-3 days) and treatment facility. Most cases and controls were treated at military or civilian medical facilities in the U.S.; however the population did include service members who sought care at military medical facilities in Europe, Korea, and Japan. Vaccination status was determined by immunization records documented in the DMSS.

Second, NHRC's analysis relied on influenza-like illness (ILI) surveillance among DoD dependent and other civilian populations living in southern

TABLE. Mid-season influenza vaccine effectiveness (VE) among different populations for the 2012-2013 influenza season

Population	Viral subtype	Vaccine type	Cases No. (% vaccinated)	Controls[a] No. (% vaccinated)	Crude VE (95% CI)	Adjusted VE[b] (95% CI)
Active component service members (AFHSC)	Overall	Any type	744 (87)	2,916 (91)	38 (18-53)	35 (14-51)
		TIV	332 (71)	1,259 (78)	39 (18-55)	35 (12-53)
		LAIV	504 (81)	1,907 (86)	37 (15-53)	34 (12-51)
Civilians and dependents (NHRC)	Overall	Any type	139 (16)	290 (45)	77 (62, 86)	72 (52, 84)
	Influenza A (H3)	Any type	90 (11)	290 (45)	82 (62, 91)	85 (69, 92)
	Influenza B	Any type	40 (28)	290 (45)	54 (4, 78)	41 (-30, 74)
Service members and dependents (USAFSAM)	Overall	Any type	628 (52)	1,008 (59)	25 (8,38)	44 (28, 56)
		LAIV	469 (35)	708 (41)	22 (1, 39)	40 (18, 56)
		TIV	462 (34)	716 (42)	27 (7, 43)	47 (29, 60)
	Influenza A (H3)	Any type	502 (52)	1,008 (59)	24 (6, 39)	48 (32, 60)
		LAIV	370 (35)	708 (41)	24 (1, 41)	44 (23, 60)
		TIV	373 (35)	716 (42)	24 (2, 42)	49 (31, 62)
	Influenza A (H1)	Any type	37 (70)	111 (63)	-38 (-209, 38)	-10 (-182, 57)
	Influenza B	Any type	87 (43)	261 (64)	58 (32, 75)	39 (-9, 65)

[a]AFHSC used healthy controls (matched to cases by sex, age, and date [+/- 3 days] and treatment facility) and NHRC and USAFSAM used unmatched influenza test negative controls.

[b]Adjusted for (1) AFHSC: prior vaccination status, (2) NHRC: age group, hospitalization status (i.e., inpatient, outpatient), days with symptoms upon presentation, and surveillance population/location, or (3) USAFSAM: age group, week of collection (and geographic region for analysis of influenza A [H1] only)

Abbreviations: AFHSC=Armed Forces Health Surveillance Center; NHRC=Naval Health Research Center; USAFSAM=United States Air Force School of Aerospace Medicine; TIV = trivalent inactivated vaccine; LAIV = live, attenuated influenza vaccine

California and Illinois during 9 December 2012 to 26 January 2013. Influenza cases were individuals who had positive laboratory tests for influenza by RT-PCR. Controls were individuals with ILI who tested negative for influenza. Vaccination status was determined by medical chart review. Individuals were considered vaccinated if their ILI diagnosis occurred more than 14 and less than 180 days since influenza vaccination.

Third, the USAFSAM assessment was conducted using global, laboratory-based influenza surveillance of service members and dependents with ILI symptoms during 30 September 2012 to 26 January 2013. Influenza cases were individuals who had positive laboratory tests for influenza by RT-PCR or viral culture. Controls were selected from ILI patients whose laboratory tests were negative for influenza. Vaccination status was obtained from Air Force electronic immunization records or the program's surveillance questionnaire.

All organizations calculated crude odds ratios and used logistic or conditional logistic regression to calculate adjusted odds ratios. VE was defined as one minus the odds ratio times 100. For example, if 10% of 50 cases were vaccinated and 40% of 50 controls were vaccinated, the odds of having been vaccinated would be 5/45=0.11 among cases and 20/30=0.67 among controls. The odds ratio is then the odds among cases divided by the odds among controls (0.11/0.67 = .16) and the VE would be calculated as 1.0 - 0.16 x 100 or 84 percent. When possible, analyses were stratified by influenza type, subtype and vaccine type (trivalent inactivated vaccine [TIV] and live attenuated influenza vaccine [LAIV]). Models were adjusted for (1) AFHSC: prior vaccination status; (2) NHRC: age group, hospitalization status (i.e., inpatient or outpatient), days with symptoms upon presentation, and surveillance population/location; and (3) USAFSAM: age group, week of collection (and geographic region for analysis of influenza A subtype H1 only).

Statistically significant findings of influenza VE ranged from 34 to 85 percent depending on the population, influenza subtype, and vaccine type **(Table)**. TIV and LAIV conferred similar levels of protection in all analyses. Vaccination coverage varied among the study populations; the highest coverage was among active component service members (AFHSC) and lowest among civilians and dependents (NHRC). Highly immunized populations (active component service members) appeared to have lower VE than less immunized populations (civilians and dependents); however, further studies would be required to properly assess this hypothesis. Models for influenza A (subtype H1) and B resulted in non-statistically significant findings; this result could be due in part to limited numbers of laboratory-confirmed influenza infections during the periods of study.

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Update: Heat Injuries, Active Component, U.S. Armed Forces, 2012

In 2012, there were more active component service members treated for heat stroke (n=365) than in 2011 but fewer than in 2008 or 2009. Compared to their respective counterparts, incidence rates of heat stroke were higher among males, those younger than 20 years of age, Marine Corps and Army members, recruit trainees, and service members in combat-specific occupations. Fewer service members were treated for "other heat injuries" in 2012 (n=2,257) than in 2010 or 2011; also, there were fewer hospitalizations for "other heat injuries" in 2012 than in any of the prior four years. The incidence rate of "other heat injuries" was higher among females than males, more than 8 times higher among recruit trainees than other enlisted members, and 20 times higher among recruit trainees than officers. From 2008 to 2012, 1,060 heat injury events occurred in Iraq/Afghanistan; 6.5 percent (n=69) were due to heat stroke.

Heat-related injuries are significant threats to the health and operational effectiveness of military members and their units.[1,2] Operational lessons learned and findings of numerous research studies have resulted in doctrine, equipment, and preventive measures that can significantly reduce the adverse health effects of military activities in heat.[1-3] Although numerous effective countermeasures are available, physical exertion in hot environments still causes many hundreds of injuries – some life threatening – among U.S. military members.[4,5]

In the U.S. Military Health System, the most serious of heat-related injuries are considered notifiable medical events. Since 31 July 2009, a notifiable case of "heat stroke" (ICD-9-CM: 992.0) has been defined as a "severe heat stress injury, specifically including injury to the central nervous system, characterized by central nervous system dysfunction and often accompanied by heat injury to other organs and tissue."[6] Notifiable cases of heat injuries other than heat stroke ("unspecified effects of heat" [ICD-9-CM: 992.9]) include "moderate to severe heat injuries associated with strenuous exercise and environmental heat stress … that require medical intervention or result in lost duty time." All heat injuries that require medical intervention or result in lost duty are reportable. Cases of "heat exhaustion" (ICD-9-CM: 992.3-992.5) that do not require medical intervention or result in lost duty time are not reportable.[6]

This report summarizes heat injury-related hospitalizations, ambulatory visits, and reportable medical events among active component members during 2012 and compares them to experiences during recent prior years. Episodes of heat stroke and "other heat injuries" are summarized separately; for this analysis, "other heat injuries" includes "heat exhaustion" (which was reportable prior to 31 July 2009) and "unspecified effects of heat" (reportable since 31 July 2009).

METHODS

The surveillance period was 1 January 2008 through 31 December 2012. The surveillance population included all individuals who served in the active components of the Army, Navy, Air Force, Marine Corps, or Coast Guard at any time during the surveillance period. The Defense Medical Surveillance System (DMSS) maintains electronic records of all actively serving U.S. military members' hospitalizations and ambulatory visits in U.S. military and civilian (contracted/purchased care through the Military Health System) medical facilities worldwide; the DMSS also maintains records of medical encounters of service members deployed to southwest Asia/Middle East (as documented in the Theater Medical Data Store [TMDS]). Because heat injuries represent a threat to the health of individual service members and to military training and operations, the Armed Forces require that such injuries be expeditiously reported as reportable medical events through one of the service specific electronic reporting systems; these reports are routinely transmitted and incorporated into the DMSS.

For this analysis, DMSS was searched to identify all records of medical encounters and notifiable medical event reports that included primary (first-listed) or secondary (second-listed) diagnoses of "heat stroke" (ICD-9-CM:992.0) or "other heat injury" ("heat exhaustion" [ICD-9-CM:992.3-992.5] and "unspecified effects of heat" [ICD-9-CM:992.9]).

This report summarizes numbers of individuals affected by documented heat injuries ("incident cases") and "heat injury events" during each calendar year. To estimate numbers of incident cases per year, each individual who was affected by a heat injury event (one or more) during a year accounted for one incident case during the respective year. To classify the severity of incident cases per year, those that were associated with any "heat stroke" diagnosis were classified as "heat stroke" cases; all others were classified as "other heat injury" cases.

To estimate total numbers of heat injury events per year, affected individuals could account for multiple events during

a year. To distinguish follow-up encounters from new heat injury events, affected service members were not considered at risk of "new" heat injury events within 60 days of prior events. Annual numbers of heat stroke and "other heat injury"-related events were estimated separately. To categorize the clinical management of heat injury events, those that were documented with hospitalization records were classified as hospitalization cases; among the others, those documented with reportable event records were prioritized over those documented by ambulatory records only.

For surveillance purposes, a "recruit trainee" was defined as an active component member in an enlisted grade of E1 to E4 who was assigned to one of the services' ten recruit training locations (per the individual's initial military personnel record). For this report, each service member was considered a recruit trainee for the period of time corresponding to the usual length of recruit training in his/her service. Recruit trainees were considered a separate category of enlisted service members in summaries of heat injuries by military grade overall.

Records of medical evacuations from the U.S. Central Command (CENTCOM) area of responsibility (AOR) (i.e., Iraq, Afghanistan) to a medical treatment facility outside the CENTCOM AOR were analyzed separately. Evacuations were considered case-defining if affected service members had at least one inpatient or outpatient heat injury medical encounter in a permanent military medical facility in the U.S. or Europe from five days before to ten days after their evacuation dates.

TABLE 1. Incident cases[a] and incidence rates[b] of heat injury, active component, U.S. Armed Forces, 2012

	Heat stroke		"Other heat injury"	
	No.	Rate[b]	No.	Rate[b]
Total	365	0.25	2,257	1.57
Sex				
Male	334	0.27	1,765	1.44
Female	31	0.15	492	2.35
Age group				
<20	47	0.56	535	6.42
20-24	157	0.35	957	2.11
25-29	81	0.23	392	1.09
30-34	43	0.19	195	0.86
35-39	21	0.13	109	0.67
40+	16	0.11	69	0.46
Race/ethnicity				
White, non-Hispanic	236	0.26	1,389	1.55
Black, non-Hispanic	65	0.29	442	1.95
Hispanic	36	0.22	255	1.57
Asian/Pacific Islander	15	0.27	96	1.70
Other/unknown	13	0.14	75	0.78
Service				
Army	220	0.40	1,395	2.54
Navy	15	0.05	132	0.42
Air Force	18	0.05	219	0.66
Marine Corps	112	0.57	492	2.49
Coast Guard	0	0.00	19	0.45
Rank				
Recruit	16	0.58	352	12.80
Enlisted	294	0.25	1752	1.51
Officer	55	0.22	153	0.62
Military occupation				
Infantry/artillery/combat engineer	136	0.67	541	2.68
Armor/motor transport	6	0.11	73	1.33
Pilot/aircrew	1	0.02	8	0.15
Repair/engineer	38	0.09	426	1.04
Communications/intelligence	50	0.16	461	1.47
Healthcare	27	0.22	148	1.21
Other	107	0.38	600	2.14
Home of record[c]				
Northeast	51	0.29	268	1.50
Midwest	70	0.28	409	1.61
South	151	0.26	1,042	1.80
West	80	0.26	454	1.45
Other/unknown	13	0.12	84	0.75

[a]One per person per year
[b]Rate per 1,000 person-years
[c]Home of record self-reported at entry into service

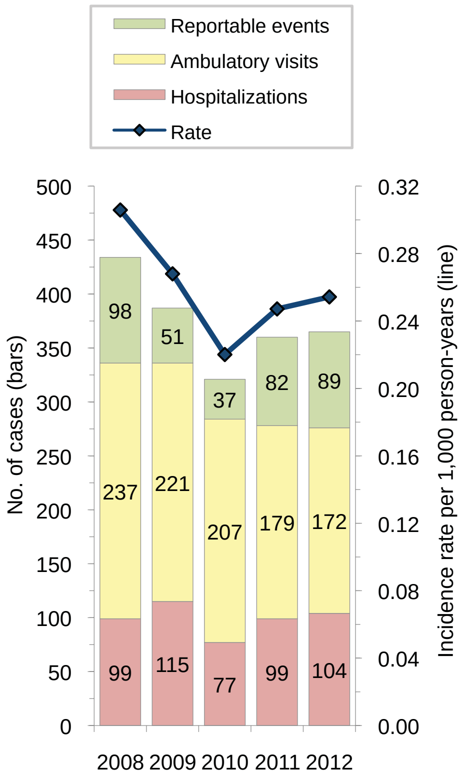
RESULTS

In 2012, there were 365 incident cases of heat stroke and 2,257 incident cases of "other heat injury" among active component members. The overall crude incidence rates of heat stroke and "other heat injury" were 0.25 and 1.57 per 1,000 person-years (p-yrs), respectively **(Table 1)**.

The annual incidence rate (unadjusted) of heat stroke in 2012 was slightly higher than in 2011 but lower than in 2008 and 2009. There were more heat stroke-related reportable events and hospitalizations in 2012 than in 2010 or 2011; however, there were fewer ambulatory visits for heat stroke in 2012 than in any other year of the period **(Figure 1)**.

The annual incidence rate (unadjusted) of "other heat injury" was lower in 2012 than in the previous two years. In 2012 compared to 2011, there were markedly fewer ambulatory visits (-26%) and hospitalizations (-41%), but six percent more reportable events for "other heat injuries" **(Figure 2)**.

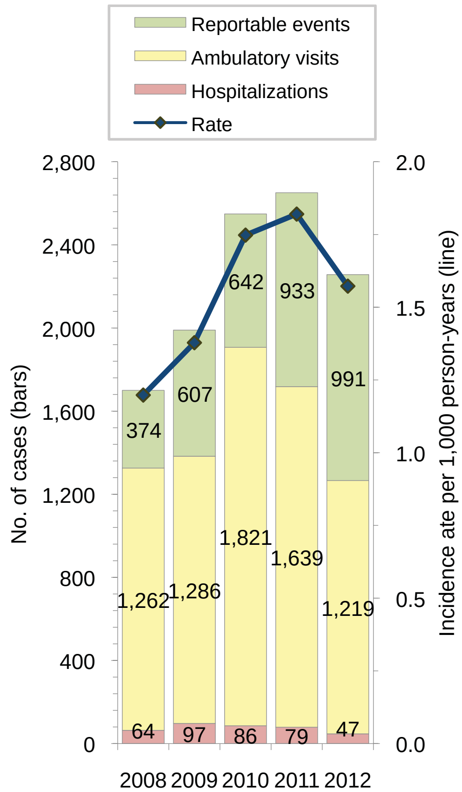
FIGURE 1. Incident cases and incidence rates of heat stroke, by source of report and year of diagnosis, active component, U.S. Armed Forces, 2008-2012



In 2012, subgroup-specific incidence rates of heat stroke were highest among service members in those younger than 20 years of age, Marine Corps members, recruit trainees, and combat-specific occupations (e.g., infantry, artillery, combat engineering) **(Table 1)**. Heat stroke rates in the Marine Corps and Army were more than seven-fold those in the other services; the rate among males was nearly twice that of females; and the rate among recruit trainees was more than twice those among other enlisted members and officers **(Table 1)**.

In contrast to the heat stroke experience, the crude incidence rate of "other heat injuries" was higher among females than males. Also of note, the rate of "other heat injuries" among recruit trainees was over 8 times that among other enlisted members and 20 times that among officers **(Table 1)**. In 2012, subgroup-specific incidence rates of "other heat injuries" were highest by far among recruit trainees and service

FIGURE 2. Incident cases and incidence rates of "other heat injury," by source of report and year of diagnosis, active component, U.S. Armed Forces, 2008-2012



members younger than 20 years of age; rates were also relatively high among Army and Marine Corps members and those in combat-specific occupations **(Table 1)**.

In 2012, 438 heat stroke events affected 365 individuals (average number of heat stroke events per affected individual: 1.2); 62 individuals experienced more than one heat stroke event during the year. The number of service members affected by more than one heat stroke event in 2012 was lower than the average per year (n=87) during the prior years of the period. Also, in 2012, 2,485 "other heat injury" events affected 2,434 individuals; this number included some individuals who were also diagnosed with heat stroke during 2012. The average number of "other heat injury" events per affected individual was 1.0; 50 individuals experienced more than one "other heat injury" event during the year. The number of service members affected by more than one "other heat injury" event in 2012 was lower than the average per year (n=71) during the prior years of the period **(data not shown)**.

Heat injuries by location

During the five-year surveillance period, heat-related injuries were diagnosed at more than 100 military installations/geographic locations worldwide. Three Army installations accounted for nearly 30 percent of all heat injury events during the period (Fort Bragg, NC [n=1,399], Fort Benning, GA [n=1,256], and Fort Jackson, SC [n=1,178]); four other installations accounted for an additional 16 percent of heat injury events (Marine Corp Recruit Training Depot [MCRD] Parris Island/Beaufort, SC [n=618], Marine Corps Base [MCB] Camp Lejeune/Cherry Point, NC [n=577], Fort Polk, LA [n=447], and Fort Campbell, KY [n=397]). Of the ten installations with the most heat injury events, eight are in the southeastern United States **(Table 2)**.

Heat injuries in Iraq and Afghanistan

During the five-year surveillance period, 1,060 heat injuries were diagnosed and treated in Iraq and Afghanistan **(Figure 3)**. Of these, 6.5 percent (n= 69) were heat stroke. Deployed service members who were affected by heat injuries were most frequently male (n=856; 80.8%), white, non-Hispanic (n=665: 62.7%), aged 20-24 years (n=554; 52.3%), in the Army (n=659; 62.2%), enlisted (n=1,011; 95.4%), and in combat–specific (e.g., infantry, artillery, combat engineering) (n=264; 24.9%) or communications/intelligence (n=255; 24.1%) occupations **(data not shown)**. During the surveillance period, 29 service members were medically evacuated for heat injuries from Iraq or Afghanistan; more than half of the evacuations (59%; n=17) took place in July and August **(data not shown)**.

EDITORIAL COMMENT

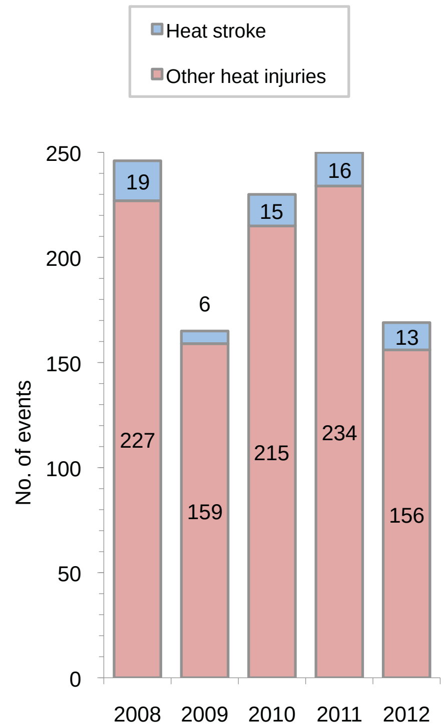
In 2012, there were more hospitalizations and reportable events for heat stroke,

TABLE 2. Heat injury events[a] by location of diagnosis/report, active component, U.S. Armed Forces, 2008-2012

Location of diagnosis	No.	% total
Fort Bragg, NC	1,399	10.7
Fort Benning, GA	1,256	9.7
Fort Jackson, SC	1,178	9.1
MCRD Parris Island/ Beaufort, SC	618	4.7
MCB Camp Lejeune/ Cherry Pt, NC	577	4.4
Fort Polk, LA	447	3.4
Fort Campbell, KY	397	3.1
MCB Camp Pendleton, CA	259	2.0
MCB Quantico, VA	255	2.0
Fort Hood, TX	253	1.9
Fort Sill, OK	248	1.9
Fort Stewart, GA	247	1.9
Lackland AFB, TX	247	1.9
NMC San Diego, CA	196	1.5
Okinawa, Japan	177	1.4
All other locations	5,260	40.4
Total	13,014	100.0

[a]One heat injury per person per 60 days

FIGURE 3. Numbers of heat injury events[a] reported from Iraq/Afghanistan, by year and type of heat injury, 2008-2012



[a]One per person per 60 days

and the incidence rate of heat stroke was higher, than in 2011. Rates of other clinically significant heat-related injuries increased from 2008 through 2011 but declined in 2012.

The results of this update should be interpreted with consideration of its limitations. For example, clinical criteria for mandatory reporting of heat-related injuries as "heat stroke" or "other heat injury" cases changed in 2009. Since that time, central nervous system dysfunction was a necessary criterion for a heat casualty to be considered a case of "heat stroke." Prior to 2009, the surveillance case definition of "heat stroke" did not require central nervous system dysfunction; as such, heat stroke cases may have had laboratory evidence of injury to the liver, muscles, or kidneys without clinical manifestations of central nervous system effects. The change likely affected the numbers and natures of heat injury-related notifiable medical event reports in 2009 through 2012.

In addition, similar heat-related clinical illnesses are likely managed differently and reported with different diagnostic codes at different locations and in different clinical settings. Such differences undermine the validity of direct comparisons of rates of nominal "heat stroke" and "other heat injury" events across locations and settings. Also, heat injuries during training exercises and deployments that are treated in field medical facilities are not completely ascertained as cases for this report.

In spite of its limitations, this report documents that heat injuries are still a significant threat to the health of U.S. military members and the effectiveness of military operations. Of all military members, the youngest and most inexperienced Marines and soldiers (particularly those training at installations in the southeastern United States) are at highest risk of heat injuries - including heat stroke, exertional hyponatremia, and exertional rhabdomyolysis (see the other articles in this issue of the *MSMR*).

Commanders, small unit leaders, training cadre, and supporting medical personnel, particularly at recruit training centers and installations with large combat troop populations, must ensure that military members whom they supervise and support are informed regarding risks, preventive countermeasures (e.g., water consumption), early signs and symptoms, and first responder actions related to heat injuries.[1-3] Leaders should be aware of the dangers of insufficient hydration on the one hand and excessive water intake on the other; they must have detailed knowledge of, and rigidly enforce countermeasures against, all types of heat injuries.

Policies, guidance, and other information related to heat injury prevention and treatment among U.S. military members are available on-line at: http://phc.amedd.army.mil/topics/discond/hipss/Pages/HeatinjuryPrevention.aspx and http://www.marines.mil/Portals/59/Publications/MCO%206200.1E%20W%20CH%201.pdf.

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Update: Exertional Rhabdomyolysis, Active Component, U.S. Armed Forces 2008-2012

In 2012, there were 402 incident episodes of rhabdomyolysis likely due to physical exertion and/or heat stress ("exertional rhabdomyolysis") among U.S. service members. The annual rates of exertional rhabdomyolysis increased 30 percent from 2008 to 2012. The highest incidence rates occurred in males, black, non-Hispanic service members, service members younger than 20 years of age, members of the Army and Marine Corps, recruit trainees, and those in combat-specific occupations. Incidence rates were higher among service members with homes of record from the Northeast compared to other regions of the U.S. Most cases were diagnosed at installations that support basic combat/recruit training or major Army or Marine Corps ground combat units. Medical care providers should consider exertional rhabdomyolysis in the differential diagnosis when service members – particularly recruits – present with muscular pain and swelling, limited range of motion, and/or the excretion of dark urine (e.g., myoglobinuria) after strenuous physical activity, particularly in hot, humid weather.

Rhabdomyolysis is the breakdown of striated muscle cells with release into the bloodstream of their potentially toxic contents. In U.S. military members, rhabdomyolysis is a significant threat during physical exertion, particularly under heat stress. Each year, the *Medical Surveillance Monthly Report (MSMR)* summarizes numbers, rates, trends, risk factors, and locations of occurrences of exertional heat injuries, including exertional rhabdomyolysis. This update covers calendar year 2012. Information regarding the definition, causes and prevention of exertional rhabdomyolysis can be found in previous issues of the *MSMR*.[1]

METHODS

The surveillance period was 1 January 2008 to 31 December 2012. The surveillance population included all individuals who served in an active component of the U.S. Armed Forces at any time during the surveillance period. The Defense Medical Surveillance System (DMSS) maintains electronic records of all actively serving U.S. military members' hospitalizations and ambulatory visits in U.S. military and civilian (contracted/purchased care through the Military Health System) medical facilities worldwide; the DMSS also maintains records of medical encounters of service members deployed to southwest Asia/Middle East (as documented in the Theater Medical Data Store [TMDS]).

For this analysis, the DMSS was searched for records of health care encounters (inpatient or outpatient) associated with diagnoses related to the occurrence of exertional rhabdomyolysis. For surveillance purposes, a case of "exertional rhabdomyolysis" was defined as a hospitalization or ambulatory visit with a discharge diagnosis in any position of: "rhabdomyolysis" (ICD-9-CM: 728.88) and/or "myoglobinuria" (ICD-9-CM: 791.3); plus a diagnosis in any position of "volume depletion (dehydration)" (ICD-9-CM: 276.5) and/or "effects of heat" (ICD-9-CM: 992.0-992.9) and/or "effects of thirst (deprivation of water)," "exhaustion due to exposure," and "exhaustion due to excessive exertion (overexertion)" (ICD-9-CM: 994.3-994.5). Each individual could be included as a case only once per calendar year.

To exclude cases of rhabdomyolysis that were secondary to traumatic injuries, intoxications, or adverse drug reactions, medical encounters with diagnoses in any position of "injury, poisoning, toxic effects" (ICD-9-CM: 800-999, except "sprains and strains of joints and adjacent muscles" ICD-9-CM: 992.0-992.9, 994.3-994.5, and 840-848) were not considered indicative of "exertional rhabdomyolysis".

For surveillance purposes, a "recruit trainee" was defined as an active component member in an enlisted grade of E1 to E4 who was assigned to one of the services' ten recruit training locations (per the individual's initial military personnel record). For this report, each service member was considered a recruit trainee for the period of time corresponding to the usual length of recruit training in his/her service. Recruit trainees were considered a separate category of enlisted service members in summaries of heat injuries by military grade overall.

Records of medical evacuations from the U.S. Central Command (CENTCOM) area of responsibility (AOR) (e.g., Iraq, Afghanistan) to a medical treatment facility outside the CENTCOM AOR were analyzed separately. Evacuations were considered case-defining if affected service members met the above criteria in a permanent military medical facility in the U.S. or Europe from five days before to ten days after their evacuation dates.

RESULTS

In 2012, there were 402 incident episodes of rhabdomyolysis likely due to physical exertion and/or heat stress ("exertional rhabdomyolysis") **(Table 1)**. The crude incidence rate was 27.8 per 100,000 person-years (p-yrs).

In 2012, relative to their respective counterparts, the highest incidence rates of exertional rhabdomyolysis affected service members who were male, younger than 20 years of age, and black, non-Hispanic. Subgroup-specific incidence rates were highest among service members in the Marine Corps and Army, in combat-specific occupations (e.g., infantry, artillery, combat engineering), and with homes of record from the Northeast region of the United States. Of note, rates among recruit trainees were five times those among other enlisted members and officers **(Table 1)**.

The annual rates of exertional rhabdomyolysis increased over 30 percent from 2008 to 2012 (20.7 and 27.6 per 100,000 p-yrs, respectively). However, from 2011 to 2012, incident diagnoses of exertional rhabdomyolysis decreased 8 percent **(Figure 1)**. In 2011 and 2012, the numbers of hospitalizations and ambulatory visits were higher than in any of the previous three years **(Figure 1)**.

In 2012, 77 percent of all service members hospitalized for exertional rhabdomyolysis were in the Army (n=92) or Marine Corps (n=56) **(Table 1)**. Hospitalization rates were higher in the Marine Corps than the other Services during every year of the surveillance period **(Figure 2)**. In all services except the Coast Guard, incidence rates of hospitalizations decreased in 2012 compared to 2011. In 2012, as in the past, most cases occurred from May through September (% of cases overall, May-September: 70%) **(data not shown)**.

TABLE 1. Incident cases and incidence rates[a] of exertional rhabdomyolysis, active component, U.S Armed Forces, 2012

	Hospitalizations		Ambulatory		Total	
	No.	Rate[a]	No.	Rate[a]	No.	Rate[a]
Total	192	13.2	210	14.6	402	27.8
Sex						
Male	182	14.6	191	15.6	373	30.2
Female	10	4.7	19	9.1	29	13.8
Age group						
<20	20	18.9	33	31.3	53	50.2
20-24	72	14.9	72	15.5	144	30.4
25-29	47	13.4	63	18.1	110	31.5
30-34	28	12.9	25	11.3	53	24.3
35-39	18	11.1	10	6.3	28	17.4
40+	7	5.1	7	5.1	14	10.1
Race/ethnicity						
White, non-Hispanic	118	12.9	127	14.2	245	27.1
Black, non-Hispanic	36	15.6	54	23.9	90	39.5
Hispanic	26	15.9	16	9.8	42	25.8
Asian/Pacific Islander	7	12.3	9	15.9	16	28.2
Other/Unknown	5	5.3	4	4.2	9	9.4
Service						
Army	92	16.3	110	20.0	202	36.3
Navy	18	5.6	16	5.1	34	10.7
Air Force	23	7.0	27	8.2	50	15.2
Marine Corps	56	27.9	55	27.8	111	55.7
Coast Guard	3	7.2	2	4.8	5	11.9
Rank						
Recruit	10	37.3	28	101.6	38	139.0
Enlisted	147	12.4	159	13.7	306	26.1
Officer	35	14.3	23	9.3	58	23.6
Military occupation						
Infantry/artillery/combat engineer	52	25.3	50	24.7	102	50.0
Armor/motor transport	4	6.8	2	3.6	6	10.4
Pilot/aircrew	2	3.8	2	3.8	4	7.6
Repair/engineer	35	8.3	40	9.8	75	18.1
Communications/ intelligence	32	10.1	40	12.7	72	22.8
Healthcare	14	11.7	10	8.2	24	19.9
Other	53	18.7	66	23.6	119	42.2
Home of record[b]						
Northeast	28	15.7	32	17.9	60	33.6
South	69	11.9	98	16.9	167	28.9
West	51	16.5	37	11.9	88	28.4
Midwest	35	13.8	37	14.6	72	28.4
Other/unknown	9	8.0	6	5.3	15	12.0

[a]Rate per 100,000 person-years
[b]Home of record self-reported at entry into service

Rhabdomyolysis by location

During the five-year surveillance period, the medical treatment facilities at five installations accounted for at least 50 cases each and nearly 40 percent of all diagnosed cases. Of these installations, two provide support to recruit/basic combat training centers (Marine Corps Recruit Depot [MCRD] Parris Island/Beaufort, SC; and Fort Jackson, SC) and three support large combat troop populations (Fort Bragg, NC; Marine Corps Base [MCB] Camp Pendleton, CA; and MCB Camp Lejeune/Cherry Pt, NC) **(Table 2)**. The most cases overall (accounting for 28% of all cases) were diagnosed at Fort Bragg, NC (n=275) and MCRD Parris Island/Beaufort, SC (n=194) **(Table 2)**.

Rhabdomyolysis in Iraq and Afghanistan

During the five year surveillance period, there were 21 incident cases of exertional rhabdomyolysis diagnosed and treated in Iraq/Afghanistan. Deployed service members who were affected by exertional rhabdomyolysis were most frequently male (n=95.2%), black, non-Hispanic (n=10; 47.6%), aged 20-24 years (n=9; 42.9%), in the Army (n=15; 71.4%), enlisted (n=19; 90.5%), and in combat-specific occupations (n=9; 42.9%). Nine active component service members were medically evacuated from Iraq/Afghanistan for

FIGURE 1. Incident diagnoses of exertional rhabdomyolysis, by clinical setting and year, active component, U.S. Armed Forces, 2008-2012

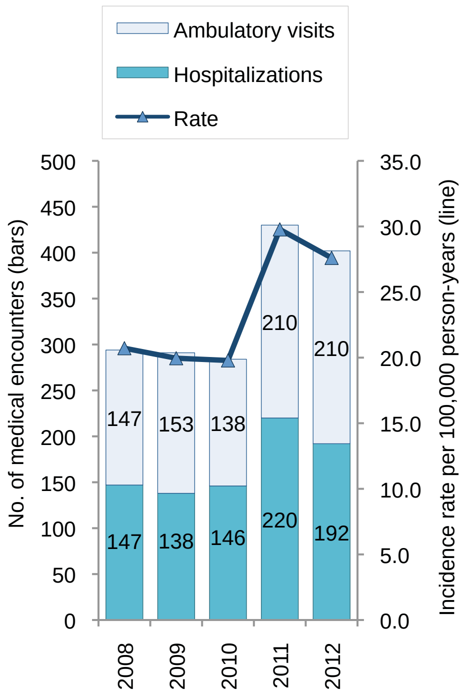

FIGURE 2. Incidence rates of hospitalizations for exertional rhabdomyolysis, by service, active component, U.S. Armed Forces, 2008-2012

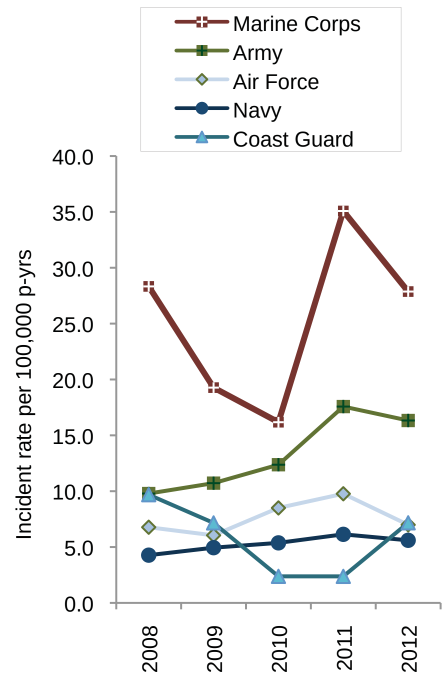

TABLE 2. Incident cases of exertional rhabdomyolysis by installation (with at least 20 cases during the period), active component, U.S. Armed Forces, 2008-2012

Location of diagnosis	No.	% total
Fort Bragg, NC	275	16.2
MCRD Parris Island/ Beaufort, SC	197	11.6
MCB Camp Pendleton, CA	74	4.4
Fort Jackson, SC	68	4.0
MCB Camp Lejeune/ Cherry Pt, NC	63	3.7
Fort Benning, GA	49	2.9
Lackland AFB, TX	49	2.9
Fort Hood, TX	46	2.7
NMC San Diego, CA	40	2.4
MCB Quantico, VA	37	2.2
Fort Belvoir, VA	31	1.8
Fort Stewart, GA	29	1.7
NMC Portsmouth, VA	29	1.7
Fort Shafter, HI	28	1.6
Fort Campbell, KY	26	1.5
Fort Bliss, TX	26	1.5
Fort Carson, CO	21	1.2
Other locations	613	36.0
Total	1,701	100.0

exertional rhabdomyolysis; all but one of these cases occurred from May through September **(data not shown)**.

EDITORIAL COMMENT

This report documents an increase in the rate of exertional rhabdomyolysis among active component members of the U.S. military in the last two years. Exertional rhabdomyolysis continues to occur most frequently from late spring through early fall at installations that support basic combat/recruit training or major Army or Marine Corps combat units.

The risks of heat injuries, including exertional rhabdomyolysis, are increased among individuals who suddenly increase overall levels of physical activity, recruits who are not physically fit when they begin training, and recruits from relatively cool and dry climates who may not be acclimated to the high heat and humidity at training camps in the summer.[2,3] Soldiers and Marines in combat units often conduct rigorous unit physical training, personal fitness training, and field training exercises regardless of weather conditions. It is not surprising, therefore, that rates are highest among recruit trainees and service members from northeastern states and that recruit camps and installations with large ground combat units account for most exertional rhabdomyolysis cases.

The higher rate in black, non-Hispanic service members compared to other racial/ethnic subgroup members may reflect, at least in part, an increased risk of exertional rhabdomyolysis among individuals with sickle cell trait.[4-6] Supervisors at all levels should assure that guidelines to prevent heat injuries are enforced for all service members. They should be vigilant for early signs of exertional heat injuries including rhabdomyolysis among all (particularly, black, non-Hispanic) service members.

The findings of this report should be interpreted with consideration of its limitations. A diagnosis of "rhabdomyolysis" alone does not indicate the cause. Ascertainment of the probable causes of cases of exertional rhabdomyolysis was attempted by using a combination of ICD-9 diagnostic codes related to rhabdomyolysis with additional codes indicative of the effects of exertion, heat, or dehydration. Further, other ICD-9 codes were used to exclude cases of rhabdomyolysis that were secondary to trauma, intoxication, or adverse drug reactions.

The measures that are effective at preventing exertional heat injuries in general apply to the prevention of exertional rhabdomyolysis. In the military training setting, the intensity and duration of exercise and adherence to prescribed work-rest cycles during strenuous physical activities should be adapted not only to ambient weather conditions but also to the fitness levels of participants in strenuous activities. The physical activities of overweight and/or

previously sedentary new recruits should increase gradually and be closely monitored. Water intake should comply with current guidelines and be closely supervised. Strenuous activities during relatively cool mornings following days of high heat stress should be particularly closely monitored; in the past, such situations have been associated with increased risk of exertional heat injuries (including rhabdomyolysis).[7] Commanders and supervisors at all levels should be aware of and alert for early signs of exertional heat injuries and should aggressively intervene when dangerous conditions, activities, or suspicious illnesses are detected.

Finally, medical care providers should consider exertional rhabdomyolysis in the differential diagnosis when service members – particularly recruits – present with muscular pain or swelling, limited range of motion, or the excretion of dark urine (possibly due to myoglobinuria) after strenuous physical activity, particularly in hot, humid weather.

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Update: Exertional Hyponatremia, Active Component, U.S. Armed Forces, 1999-2012

From 1999 through 2012, there were 1,333 incident diagnoses of exertional hyponatremia among active component members of the U.S. Armed Forces. Annual incidence rates rose sharply from 2008 to 2010 but have since decreased by 50 percent from 2010 to 2012. In 2012, there were fewer incident cases (n=84) than in any of the previous six years. The recent decrease in rates overall reflects sharply declining rates in the Marine Corps and slight decreases in the other services. Relative to their respective counterparts, crude incidence rates of exertional hyponatremia for the entire 14 year surveillance period were higher among females, those in the youngest age group, Marines, recruit trainees, and "other" military occupations. Service members (particularly recruit trainees) and their supervisors must be vigilant for early signs of heat-related illnesses and must be knowledgeable of the dangers of excessive water consumption and the prescribed limits for water intake during prolonged physical activity – e.g., field training exercises, personal fitness training, recreational activities – in hot, humid weather.

Hyponatremia, which is defined as a low concentration of sodium in the blood (i.e., serum sodium concentration <135 mEq/L), can have serious and sometimes fatal clinical effects.[1,2] In otherwise healthy, physically active young adults (e.g., long distance runners, military recruits), hyponatremia is often associated with excessive water consumption, excessive sodium losses in sweat, and inadequate sodium intake during prolonged physical exertion ("exertional hyponatremia"), particularly during heat stress.[1-4]

Acute hyponatremia creates an osmotic imbalance between fluids outside and inside of cells. The osmotic gradient causes water to flow from outside to inside the cells of various organs, including the lungs ("pulmonary edema") and brain ("cerebral edema"). Swelling of the brain increases intracranial pressure which can decrease cerebral blood flow and disrupt brain function (e.g., hypotonic encephalopathy, seizures, coma). Without rapid and definitive treatment to relieve increasing intracranial pressure, the brain stem can herniate through the base of the skull, and life sustaining functions that are controlled by the cardio-respiratory centers of the brain stem can be compromised.[1-3]

In the summer of 1997, Army training centers reported five hospitalizations of soldiers for hyponatremia secondary to excessive water consumption during military training in hot weather – one case was fatal and several others required intensive medical care.[5] In April 1998, the U.S. Army Research Institute of Environmental Medicine (USARIEM), Natick, Massachusetts, revised the guidelines for fluid replacement during military training in heat. The new guidelines were designed to protect service members not only from heat injury but also from hyponatremia due to excessive water consumption. The guidelines limited fluid intake regardless of heat category or work level to no more than 1½ quarts hourly and 12 quarts daily.[6] There were fewer hospitalizations of soldiers for hyponatremia due to excessive water consumption during the year after compared to before implementation of the new guidelines.[6]

This report uses a surveillance case definition for "exertional hyponatremia" to estimate frequencies, rates, trends, geographic locations, and demographic and military characteristics of exertional hyponatremia cases among U.S. military members from 1999 through 2012.

METHODS

The surveillance period was 1 January 1999 to 31 December 2012. The surveillance population included all individuals who served in an active component of the U.S. Armed Forces at any time during the surveillance period. The Defense Medical Surveillance System (DMSS) maintains electronic records of all actively serving U.S. military members' hospitalizations and ambulatory visits in U.S. military and civilian (contracted/purchased care through the Military Health System) medical facilities worldwide; the DMSS also maintains records of medical encounters of service members deployed to southwest Asia/Middle East (as documented in the Theater Medical Data Store [TMDS]).

For surveillance purposes, a case of exertional hyponatremia was defined as a hospitalization or ambulatory visit with a primary (first-listed) diagnosis of "hyposmolality and/or hyponatremia" (ICD-9-CM: 276.1) and no other illness or injury-specific diagnoses (ICD-9-CM: 001-999) in any diagnostic position; or both a diagnosis of "hyposmolality and/or hyponatremia" (ICD-9-CM: 276.1) and at least one of the following within the first three diagnostic positions (dx1-dx3): "fluid overload" (ICD-9-CM: 276.6), "alteration of consciousness" (ICD-9-CM: 780.0x), "convulsions" (ICD-9-CM: 780.39), "altered mental status" (ICD-9-CM: 780.97), "effects of heat/light" (ICD-9-CM: 992.0-992.9), or "rhabdomyolysis" (ICD-9-CM: 728.88).

Medical encounters were not considered case defining events if they included complicating diagnoses such as alcohol/illicit drug abuse; psychosis, depression, or other major mental disorders; endocrine (e.g., pituitary, adrenal) disorders; kidney diseases; intestinal infectious diseases; cancers; major traumatic injuries;

or complications of medical care in any diagnostic position. Each individual could be included as a case only once per calendar year.

For surveillance purposes, a “recruit trainee” was defined as an active component member in an enlisted grade of E1 to E4 who was assigned to one of the services’ ten recruit training locations (per the individual’s initial military personnel record). For this report, each service member was considered a recruit trainee for the period of time corresponding to the usual length of recruit training in his/her service. Recruit trainees were considered a separate category of enlisted service members in summaries of exertional hyponatremia by military grade overall.

Records of medical evacuations from the U.S. Central Command (CENTCOM) area of responsibility (AOR) (e.g., Iraq, Afghanistan) to a medical treatment facility outside the CENTCOM AOR were analyzed separately. Evacuations were considered case-defining if the affected service members met the above criteria in a permanent military medical facility in the U.S. or Europe from five days before to ten days after their evacuation dates.

TABLE 1. Incident diagnoses and incidence rates[a] of exertional hyponatremia, active component, U.S. Armed Forces, 1999-2012

	2012		Total 1999-2012	
	No.	Rate[a]	No.	Rate[a]
Total	84	5.9	1,333	6.7
Sex				
Male	77	6.3	1,106	6.5
Female	7	3.3	227	7.9
Age				
<20	7	8.4	195	13.4
20-24	23	5.1	415	6.3
25-29	22	6.1	246	5.6
30-34	6	2.6	130	4.4
35-39	12	7.4	152	6.0
40+	14	9.2	195	9.3
Race/ethnicity				
White, non-hispanic	61	6.8	921	7.3
Black, non-hispanic	8	3.5	159	4.6
Hispanic	9	5.5	132	6.5
Asian/Pacific Islander	4	7.1	51	6.6
Other/unknown	2	2.1	70	5.9
Service				
Army	30	5.5	468	6.6
Navy	10	3.2	188	3.9
Air Force	22	6.7	285	5.9
Marine Corps	21	10.6	371	14.4
Coast Guard	1	2.4	21	3.8
Rank				
Recruit	5	18.2	119	29.6
Enlisted	63	5.4	985	6.0
Officer	16	6.5	229	7.0
Military occupation				
Infantry/artillery/ combat engineer	12	5.9	194	7.8
Armor/motor transport	2	3.6	49	5.6
Pilot/aircrew	1	1.9	39	5.2
Repair/engineer	15	3.7	246	4.2
Communications/ intelligence	12	3.8	220	4.9
Health care	7	5.7	109	6.7
Other	35	12.5	476	12.4
Home of record[b]				
Northeast	10	5.6	168	7.2
South	36	6.2	509	7.0
Midwest	20	7.9	207	6.6
West	11	3.5	217	5.8
Other/unknown	7	6.2	232	6.8

[a]Rate per 100,000 person-years
[b]Home of record self-reported at entry into service

RESULTS

From 1999 through 2012, permanent medical facilities reported 1,333 incident diagnoses of exertional hyponatremia among active component members (incidence rate: 6.7 per 100,000 person-years [p-yrs]) **(Table 1)**. In 2012, there were 84 incident diagnoses of exertional hyponatremia (incidence rate: 5.9 per 100,000 p-yrs) among active component members **(Table 1)**.

From 2008 to 2010, incident cases and incidence rates increased by 75 percent **(Figure 1)**. However, since the peak in 2010 (12.6 per 100,000 p-yrs) incidence rates have decreased by 50 percent; of note, there were fewer incident cases in 2012 (n=84) than in any of the previous six years **(Figure 1)**.

In 2012, among the Services, the most cases were in the Army (n=30), but the highest overall incidence rate was in the Marine Corps (10.6 per 100,000 p-yrs) **(Table 1)**. During the 14-year surveillance period, the overall crude incidence rate was highest in the Marine Corps (14.4 per 100,000 p-yrs), intermediate in the Army and Air Force (6.6 and 5.9 per 100,000 p-yrs, respectively), and lowest in the Navy and Coast Guard (3.9 and 3.8 per 100,000 p-yrs, respectively) **(Table 1, Figure 2)**. In the Marine Corps, the annual crude rate increased by more than 3-fold between 2002 and 2010, then decreased markedly in 2011 and 2012. In each service, incidence rates decreased from 2011 to 2012 **(Figure 2)**.

In 2012, 92 percent of exertional hyponatremia cases (n=77) affected males, and the rate during the year was nearly twice as high among males (6.3 per 100,000 p-yrs) as females (3.3 per 100,000 p-yrs). However,

FIGURE 1. Incident diagnoses and incidence rates of exertional hyponatremia, active component, U.S. service members, 1999-2012

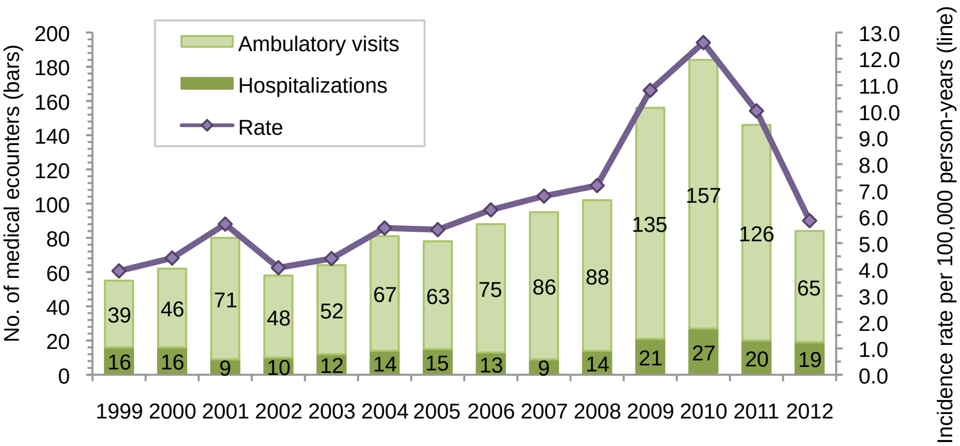

FIGURE 2. Incidence rates of exertional hyponatremia by service, active component, U.S. service members, 1999-2012

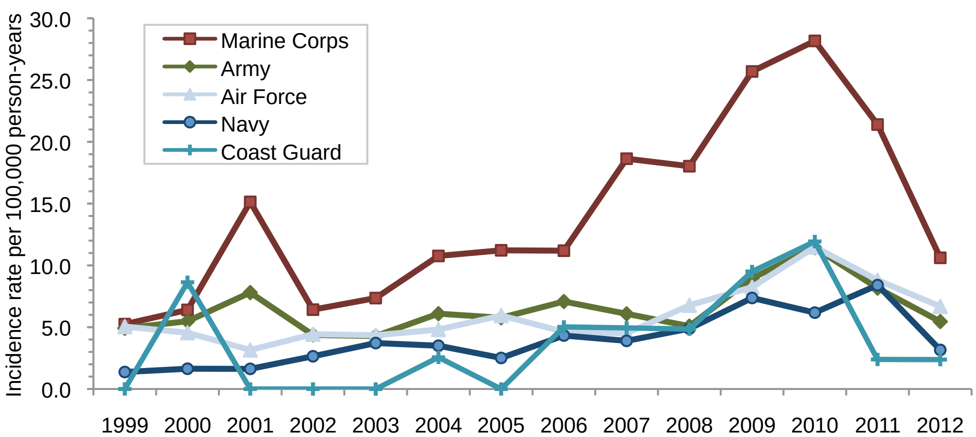

TABLE 2. Incident cases of exertional hyponatremia by installation (with at least 20 cases during the period), active component, U.S. Armed Forces, 1999-2012

Location of diagnosis	No.	%
MCRD Parris Island/ Beaufort, SC	174	13.1
Fort Benning, GA	85	6.4
Lackland AFB, TX	46	3.5
MCB Camp Lejeune/ Cherry Pt, NC	45	3.4
Walter Reed NMMC, MD[a]	42	3.2
Fort Bragg, NC	37	2.8
NMC Portsmouth, VA	34	2.6
MCB Camp Pendleton, CA	33	2.5
NMC San Diego, CA	33	2.5
Fort Jackson, SC	30	2.3
MCB Quantico, VA	25	1.9
Fort Leonard Wood, MO	23	1.7
Other locations	726	54.5
Total	1,333	100.0

[a]Walter Reed National Military Medical Center (NMMC) is a consolidation of National Naval Medical Center (Bethesda, MD) and Walter Reed Army Medical Center (Washington, DC). This number represents the sum of the two sites prior to the consolidation (Nov 2011) and the number reported at the consolidated location.

over the entire surveillance period, the incidence rate was higher among females than males **(Table 1)**.

In 2012 and during the surveillance period overall, the highest age group-specific incidence rates affected the youngest (<20 years) and oldest (>39 years) service members. Also, during the period overall, rates were higher among white, non-Hispanic than other racial/ethnic groups of service members **(Table 1)**. Rates among recruit trainees were more than double in 2012 and quadruple overall the rates among other enlisted members and officers. Among categories of military occupations, service members in "other" occupations had the highest rates. There were not consistent relationships between exertional hyponatremia rates and home of record **(Table 1)**.

Exertional hyponatremia by location

During the 14-year surveillance period, exertional hyponatremia cases were diagnosed at U.S. military medical facilities at more than 200 locations; however, five locations were affected by 40 or more cases each and accounted for nearly one-third of all cases **(Table 2)**. The location with the most cases overall was the Marine Corps Recruit Depot (MCRD) Parris Island/Beaufort, SC (n=174). Of note, at MCRD Parris Island/Beaufort, there were 81 percent fewer cases in 2012 (n=6) than in 2009 (n=32, the most cases reported in one year from any location) **(data not shown)**.

Exertional hyponatremia in Iraq and Afghanistan

From 2005 to 2012, 98 cases of exertional hyponatremia were diagnosed and treated in Iraq and Afghanistan. Deployed service members who were affected by exertional hyponatremia were most frequently male (n=71; 72.4%), white, non-Hispanic (n=58; 59.2%), aged 20-24 years (n=38; 38.8%), in the Army (n=67; 68.4%), enlisted (n=85; 86.7%), and in communications/intelligence (n=23; 23.5%) and repair/engineering (n=21; 21.4%) occupations

(data not shown). During the entire period, only five service members were medically evacuated from Iraq or Afghanistan for exertional hyponatremia **(data not shown).**

EDITORIAL COMMENT

This report documents that, after a long period of increasing numbers and rates of exertional hyponatremia diagnoses among active component U.S. military members, numbers and rates of diagnoses have sharply declined since 2010. In the last two years, rates have declined in all of the Services, but particularly in the Marine Corps.

The results of this report should be interpreted with consideration of several limitations. For example, there is not a diagnostic code specific for "exertional hyponatremia." Thus, for surveillance purposes, cases of presumed exertional hyponatremia were ascertained from records of medical encounters that included diagnoses of "hyposmolality and/or hyponatremia," but not of other conditions (e.g., metabolic, renal, psychiatric, or iatrogenic disorders) that increase the risk of hyponatremia in the absence of physical exertion or heat stress. As such, the results of this analysis should be considered estimates of the actual incidence of symptomatic exertional hyponatremia from excessive water consumption among U.S. military members. The accuracy of estimated numbers, rates, trends, and correlates of risk depends on the completeness and accuracy of diagnoses that are reported on standardized records of relevant medical encounters. As a result, an increase in reporting of diagnoses indicative of exertional hyponatremia may reflect, at least in part, increasing awareness of, concern regarding, and aggressive management of incipient cases by military supervisors and primary health care providers.

In the past, concerns regarding hyponatremia from excessive water consumption were focused at training – particularly recruit training – installations. In this analysis, rates were relatively high among the youngest – hence, the most junior – service members, and the most cases were diagnosed at medical facilities that support large recruit training centers and large Army and Marine Corps combat units (e.g., MCRD Parris Island/Beaufort, SC; Fort Benning, GA; Camp Lejeune/Cherry Point, NC; Fort Bragg, NC). In many circumstances (e.g., recruit training, Ranger School), military trainees rigorously adhere to standardized training schedules – regardless of weather conditions. In hot, humid weather, commanders, supervisors, instructors, and medical support staff must be aware of and enforce guidelines for work-rest cycles and water consumption.

In regard to hyponatremia, service members and their supervisors must be knowledgeable of the dangers of excessive water consumption and the prescribed limits for water intake during prolonged physical activity – e.g., field training exercises, personal fitness training, recreational activities – in hot, humid weather. The current U.S. Military fluid replacement guidelines can be found at: http://hprc-online.org/nutrition/hprc-articles/files/current-u-s-military-fluid-replacement.

Women had relatively high rates over the entire period, but not in 2012; women may be at greater risk because of lower fluid requirements and longer periods of exposure to risk during some training exercises (e.g., land navigation courses, load-bearing marches).[4] Service members (particularly recruit trainees and women) and their supervisors must be vigilant for early signs of heat-related illnesses – and immediately and appropriately (but not excessively) intervene in such cases.

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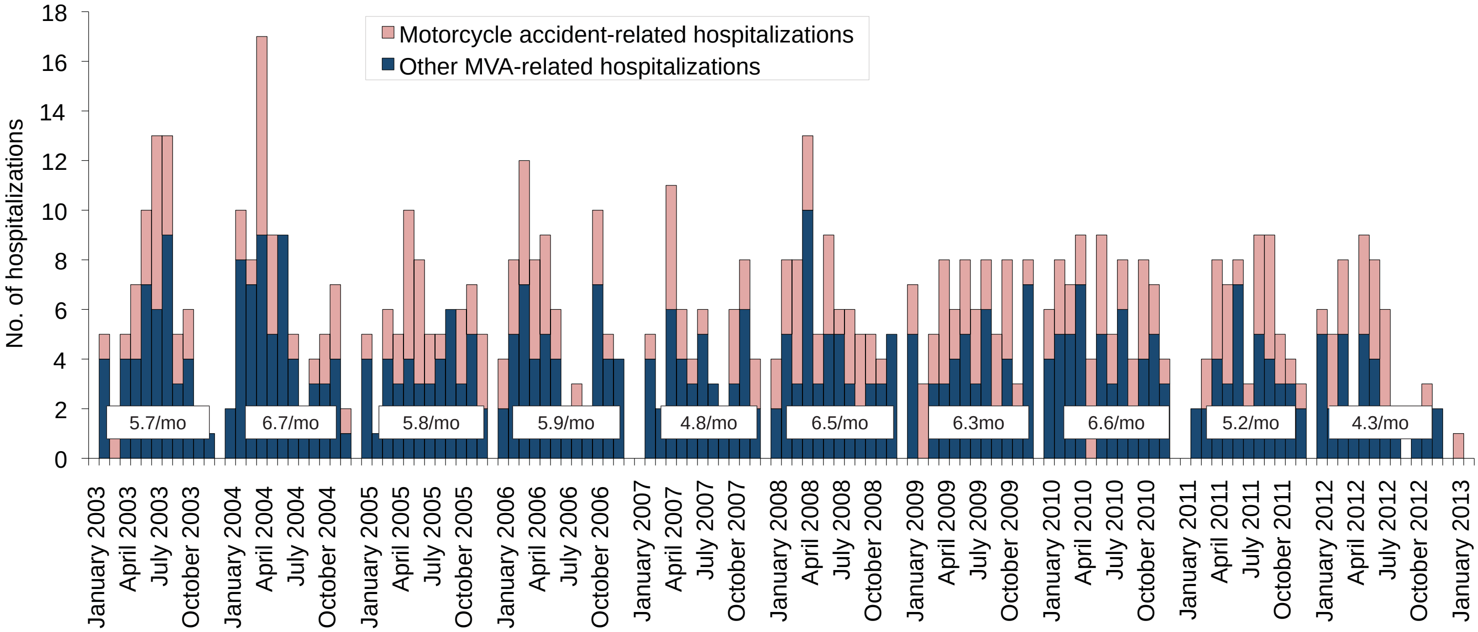
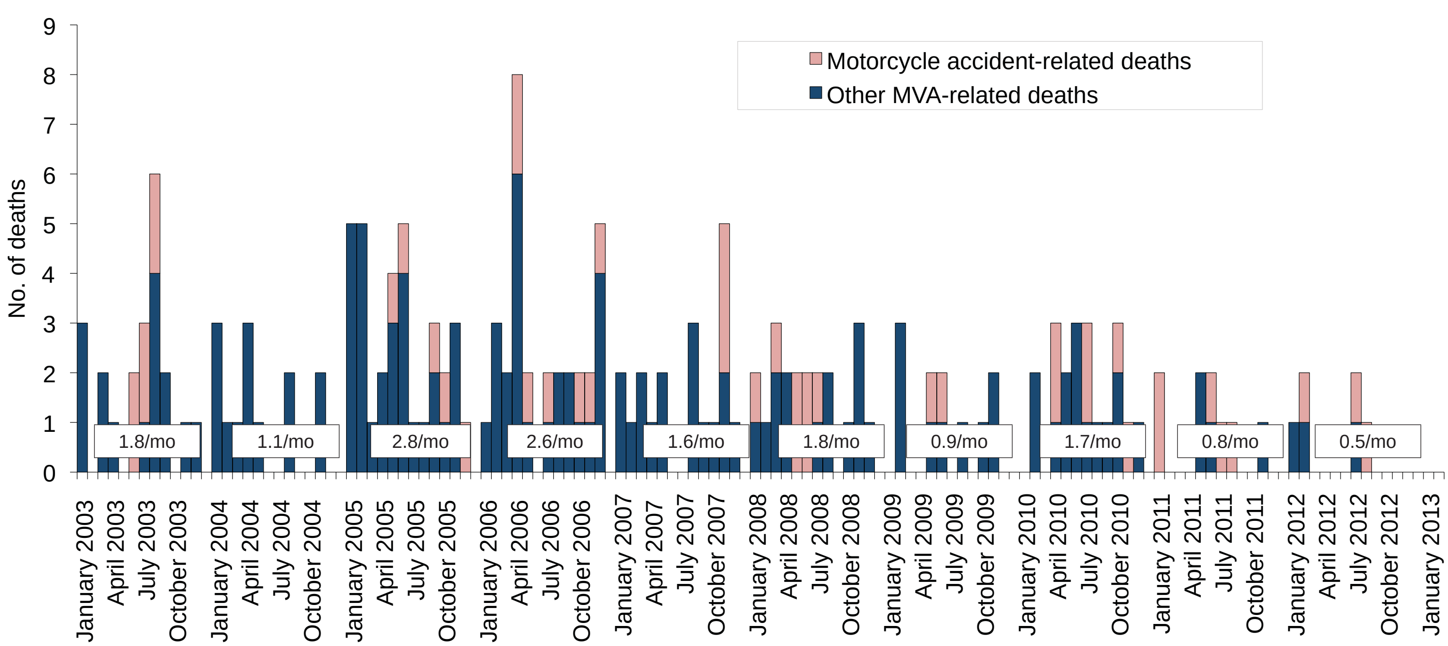
Deployment-Related Conditions of Special Surveillance Interest, U.S. Armed Forces, by Month and Service, January 2003-February 2013 (data as of 18 March 2013)

Hospitalizations outside of the operational theater for motor vehicle accidents occurring in non-military vehicles (ICD-9-CM: E810-E825; NATO Standard Agreement 2050 (STANAG): 100-106, 107-109, 120-126, 127-129)



Note: Hospitalization (one per individual) while deployed to/within 90 days of returning from OEF/OIF/OND. Excludes accidents involving military-owned/special use motor vehicles. Excludes individuals medically evacuated from CENTCOM and/or hospitalized in Landstuhl, Germany within 10 days of another motor vehicle accident-related hospitalization.

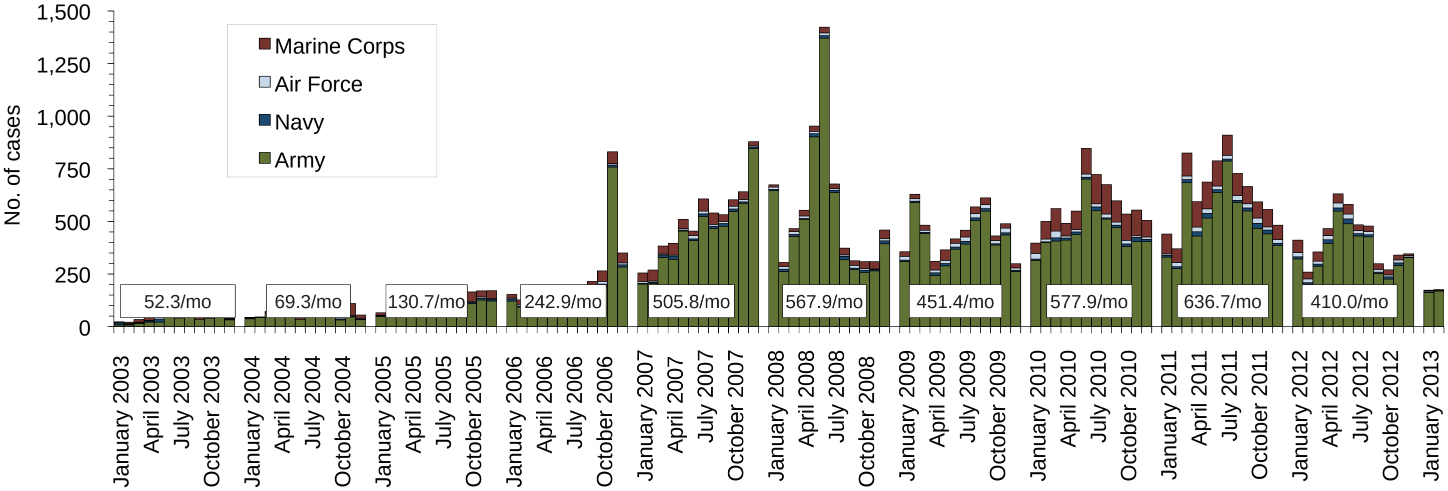
Deaths following motor vehicle accidents occurring in non-military vehicles and outside of the operational theater (per the DoD Medical Mortality Registry)[a]



[a]Data pertaining to deaths that occurred since the fall of 2012 is incomplete.
Reference: Armed Forces Health Surveillance Center. Motor vehicle-related deaths, U.S. Armed Forces, 2010. Medical Surveillance Monthly Report (*MSMR*). Mar 11;17(3):2-6.
Note: Death while deployed to/within 90 days of returning from OEF/OIF/OND. Excludes accidents involving military-owned/special use motor vehicles. Excludes individuals medically evacuated from CENTCOM and/or hospitalized in Landstuhl, Germany within 10 days prior to death.

Deployment-Related Conditions of Special Surveillance Interest, U.S. Armed Forces, by Month and Service, January 2003-February 2013 (data as of 18 March 2013)

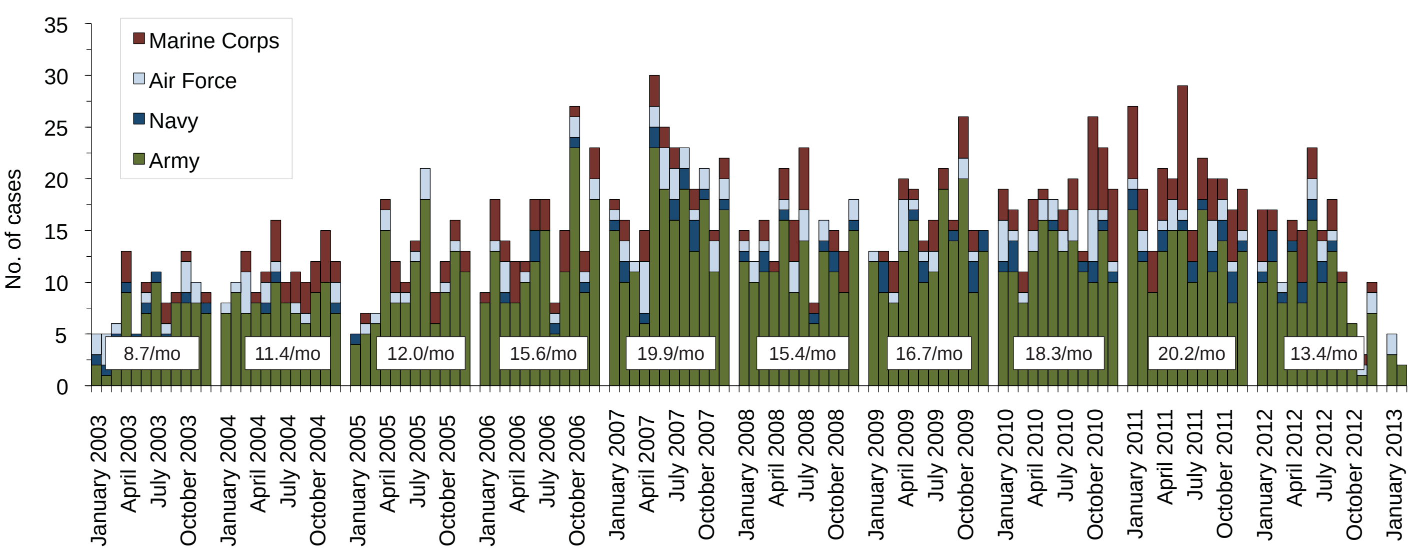
Traumatic brain injury (ICD-9: 310.2, 800-801, 803-804, 850-854, 907.0, 950.1-950.3, 959.01, V15.5_1-9, V15.5_A-F, V15.52_0-9, V15.52_A-F, V15.59_1-9, V15.59_A-F)[a]



Reference: Armed Forces Health Surveillance Center. Deriving case counts from medical encounter data: considerations when interpreting health surveillance reports. *MSMR*. Dec 2009; 16(12):2-8.

[a]Indicator diagnosis (one per individual) during a hospitalization or ambulatory visit while deployed to/within 30 days of returning from OEF/OIF. (Includes in-theater medical encounters from the Theater Medical Data Store [TMDS] and excludes 3,084 deployers who had at least one TBI-related medical encounter any time prior to OEF/OIF).

Deep vein thrombophlebitis/pulmonary embolus (ICD-9: 415.1, 451.1, 451.81, 451.83, 451.89, 453.2, 453.40 - 453.42 and 453.8)[b]

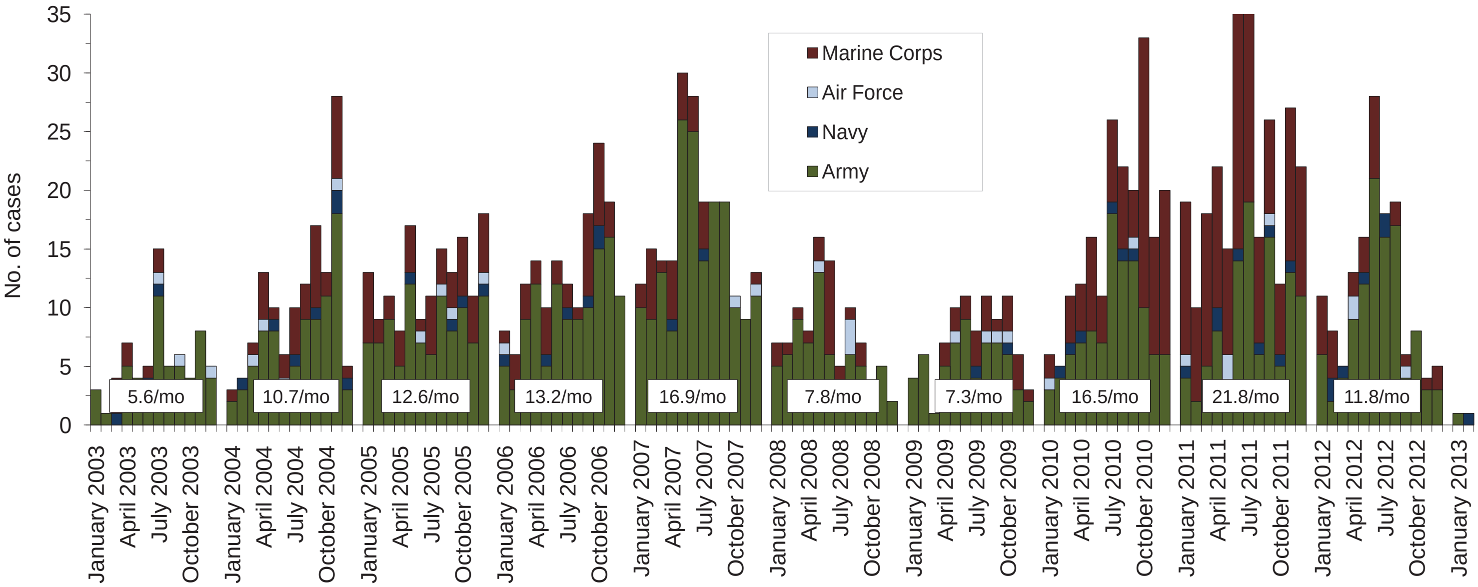


Reference: Isenbarger DW, Atwood JE, Scott PT, et al. Venous thromboembolism among United States soldiers deployed to Southwest Asia. *Thromb Res*. 2006;117(4):379-83.

[b]One diagnosis during a hospitalization or two or more ambulatory visits at least 7 days apart (one case per individual) while deployed to/within 90 days of returning from OEF/OIF.

Deployment-Related Conditions of Special Surveillance Interest, U.S. Armed Forces, by Month and Service, January 2003-February 2013 (data as of 18 March 2013)

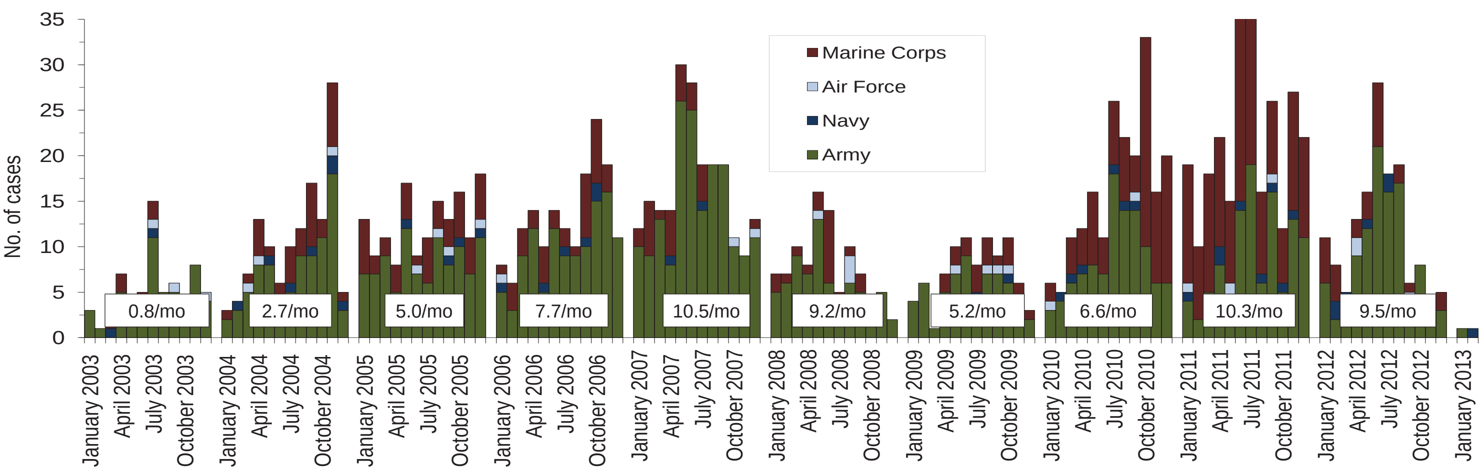
Amputations (ICD-9-CM: 887, 896, 897, V49.6 except V49.61-V49.62, V49.7 except V49.71-V49.72, PR 84.0-PR 84.1, except PR 84.01-PR 84.02 and PR 84.11)[a]



Reference: Army Medical Surveillance Activity. Deployment-related condition of special surveillance interest: amputations. Amputations of lower and upper extremities, U.S. Armed Forces, 1990-2004. *MSMR*. Jan 2005;11(1):2-6.

[a]Indicator diagnosis (one per individual) during a hospitalization while deployed to/within 365 days of returning from OEF/OIF/OND.

Heterotopic ossification (ICD-9: 728.12, 728.13, 728.19)[b]



Reference: Army Medical Surveillance Activity. Heterotopic ossification, active components, U.S. Armed Forces, 2002-2007. *MSMR*. Aug 2007; 14(5):7-9.

[b]One diagnosis during a hospitalization or two or more ambulatory visits at least 7 days apart (one case per individual) while deployed to/within 365 days of returning from OEF/OIF/OND.

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